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Jurnal quyidagi bazalarda indekslanadi:

MUNDARIJA

Ma'lumki, dunyo hamjamiyatida o'z o'rni, nufuzi va salohiyatiga ega bo'lib borayotgan yangi O'zbekiston global axborot maydonida sodir bo'layotgan xilma-xil jarayonlarning barchasiga faol ishtirok etmoqda. Bu kengqamrovli holat, bizningcha, asosan axborot-kommunikativ texnologiyalari tushunchalari yangilanayotganida, informatika fani jiddiy evrilishga yuz tutayotganida yaqqol ko'zga tashlanmoqda. Boshqacha aytadigan bo'lsak, ommaviy kommunikatsiya-muloqot odamlar kundalik hayotining ajralmas, tarkibiy bir qismiga aylana borayotganida, an'anaviy va zamonaviy ommaviy axborot vositalari o'rtasidagi tafovutlar soha egalarini raqobat maydoniga chorlayotganida namoyon bo'lmoqda.

Bu sanab o'tilayotgan omillarning asosiy sababi shuki, hozirgi zamonda insoniyat hayotining bosh xususiyati muttasil, uzluksiz o'zgarish va yangilanishlardan iborat bo'lib borayotganidir. Bu o'zgarishlarning misli ko'rilmagan shiddatli sur'atlarda kechayotgani biz yashab turgan davr va zamonning yana bir xos xususiyati desak, aslo yanglishmagan bo'lamiz. Ana

shu shiddatli o'zgarishlarning bosh omili hamda sababchisi AXBOROT ekani esa jahon afkor ommasi oydinlari tomonidan allqachon e'tirof etilgan.

"AL-FARG'ONIY AVLODLARI" – HAMKORIMIZ

Globallashuv deb atalmish sirli-sehrli jarayonning lokomotivi bo'lgan axborot yangi asr odamlarini, ularning dunyoqarashlarini, urf-odatlarni, qadriyat va an'analarni, binobarin, xalq va jamiyatni, mamlakat va davlatlar tanlab olgan yo'l va yo'nalishlarni jiddiy isloh qilmoqda. Global miqyosda sodir bo'layotgan muloqotu munosabatlarni sira ham kutilmagan, sinalmagan, noodatiy o'zanlarga burib yubormoqda. Binobarin, barcha zamondoshlarimizning bugungi kuni, ertasi hamda yaqin va uzoq kelajakdagi istiqboli ularning axborotga, shiddatli axborot oqimiga ongli munosabatlaridan kelib chiqib belgilanmoqda.

Biz yashab turgan va oddiy ishtirokchisiga aylanib borayotgan hozirgi vaziyat va mavjud holatning hayratlanarli darajadagi o'ziga xosligi shundaki, jahonni va insonni o'zgarishga majbur etayotgan axborotning va axborot sarhadlarining o'zi ham o'zgarish hamda yangilanish jarayonini boshdan kechirmoqda. Yaqin o'tmishda biron-bir axborotning istalgan soniyalar ichida jahonga tarqalib ketishi mumkinligi hayratlanarli voqealardan hisoblanardi. Biroq bunday fakt-raqam yoki hodisa bilan bugungi asrdoshlarimizni lol qila olmaymiz. Sodda qilib aytadigan bo'lsak, asrimiz odamlari tezkor zamon sur'atlariga ham, axborot vositalarining mislsiz imkoniyatlariga o'ziga xos ko'nikma hosil qildi, internet tarmoqlari ommalashgani sayin axborot kommunikatsiya vositalari deb atalayotgan atama barcha sohalarda peshqadamlikni qo'lga kiritganini anglab yetdi.

Muxtasar qilib aytadigan bo'lsak, barcha mamlakatlar qatori bizning respublikamizda ham keyingi 4-5 yil mobaynida xalqimiz hayotida aql bovar qilmaydigan darajadagi ulkan ommaviy muloqot maydoni vujudga keldi. Biz mazkur yangi ilmiy jurnalga yozayotgan so'zboshimizni axborot texnologiyalari xususidagi kengqamrovli fikrlardan, yanada aniqrog'i, birmuncha falsafiy mazmundagi mulohazalardan boshlayotganimizning ham o'ziga xos sabablari bor. Biz ishlab faoliyat yuritib turgan Toshkent axborot texnologiyalari universiteti Farg'ona filialining birinchi qaldirg'och elektron nashri – "Al-Farg'oniy avlodlari" jurnali yuqorida ta'kidlab o'tganimiz mislsiz ommaviy axborot muhitining oliy ma'lumotli mutaxassislarini tayyorlashga xizmat qiluvchi muhim minbarlardan biri bo'lib qolishga yo'naltirilgan. Fikrimizcha, davlatimiz rahbarining, hayotimizdagi har qanday

maqsadu maslak, avvalo, ilm-fanga asoslanmog'i zarur, degan fikrlari boshqa barcha sohalardan ham ko'ra eng avvalo axborot texnologiyalari sohasiga yetuk, zamonaviy mutaxassislar tarbiyalab yetishtirib beruvchi TATU va uning filiallari faoliyatiga taalluqlidir. Axir malakali soha mutaxassislarini tarbiyalab yetishtirish bilan bir qatorda kundalik hayot muntazam ravishda ko'ndalang qo'yayotgan muammolarning har jihatdan to'g'ri va mantiqiy ilmiy yechimlarini o'z vaqtida topish, bu muammolarni ilmiy-nazariy asoslash va tahlil qilish hamda hayotga tatbiq etish o'z-o'zidan amalga oshib qolmaydi. Buning uchun albatta sohaning salohiyatli mutaxassislari safini kengaytirish va yanada mustahkamlash taqozo etiladi. Keyingi 10-15 yil ichida TATU va uning mavjud filiallarida yosh va iqtidorli tadqiqotchilar, olisni ko'zlab izlanishlar olib borayotgan olim va olimalarning yetishib chiqayotgani yaqin kelajakda o'z samarasini berishiga shak-shubha yo'q.

Ikki og'iz so'z elektron jurnalning nomlanishi haqida. Sharq Uyg'onishining yetuk allomalaridan biri bo'lgan, Yevropada "Alfraganus" nomi bilan shuhrat qozongan Ahmad al-Farg'oniy (to'liq ismi sharifi Shixobiddin Abul Abbos Ahmad ibn Muhammad ibn Kasir al-Farg'oniy) o'z nomi o'zi bilan biz yashab turgan ko'hna va navqiron Farg'ona vodiysining, yana ham aniqrog'i, Farg'ona viloyatining daho farzandlaridan biridir. Movarounnahr, jumladan, Farg'ona arab xalifaligi tarkibiga kirganidan so'ng bu yerlarda xalqning ijtimoiy-iqtisodiy hayotida dastlab birmuncha muddat turg'unlik yuz beradi. Biroq oradan ma'lum vaqt o'tgach, xalifalikda fan va madaniyatning qudratli rivojlanishi sodir bo'ladi. Muhimi shuki, Markaziy Osiyo xalqlari ham bu jarayonda boshqa xalqlar qatori faol ishtirok etadilar. Ayni shu davrda xalifalik tarkibiga kirgan xalqlar "islom madaniyati" deb ataladigan, lekin aslida turli xalqlar madaniyatlarining o'zaro birlashib ketishi natijasida yuzaga kelgan yagona madaniy harakatning ishtirokchilari bo'lib qoldilar. Turli xalqlar orasidan yetishib chiqqan olimlar o'z ilmiy asarlarini arab tilida yozdilar. Markaziy Osiyolik barcha olimlar qatorida Ahmad al-Farg'oniy ham o'z asarlarini shu tilda yaratgan. Bu esa kelib chiqishiga ko'ra turli xalqlarga mansub bo'lgan olimlarga barcha zamonlardagi mashhur allomalarning ilmiy meroslaridan bahramand bo'lish imkonini berdi. Bu davr – Sharq mamlakatlaridagi birinchi Uyg'onish davrini boshlab bergan IX asr edi. Xuddi shu asrning o'zida aniq fanlar – tibbiyot, matematika, astronomiyaning jo'shqin rivojlanish hodisasi namoyon bo'ldi, shu bilan bir qatorda ijtimoiy fanlar, ayniqsa, kalom (teologiya), tarixnavislik, tilshunoslik va shunga o'xshash fanlar sohasida ham ulkan odimlar tashlandi.

Xullas, Ahmad al-Farg'oniy davri bo'lmish VIII asr oxiri va IX asr boshlari ana shunday beqiyos yuksalishlarni maydonga keltirgan "insoniyatning yulduzli onlari" sifatida tarixga muhrlandi. Farg'oniy va uning zamondoshlari bo'lmish mutafakkirlar ijodiga oid tadqiqot va maqolalarni qayta-qayta mutolaa qilar ekanmiz, beixtiyor bir fikrdan hayratga tushaverasan kishi: ular ilmni, ilmiy izlanish va kashfiyotlarni bunchalar ham sevmasalar va hurmat qilmasalar?! Ilm-fanga bu qadar mislsiz kuchli mehr-muhabbat va mustahkam e'tiqodni ular qaerdan, qanday omillardan oldilar ekan? Bu mulohazalarimizning yaqqol dalili sifatida Beruniyning quyidagi so'zlarini ketirish kifoya bo'lsa kerak: "Ilm o'z zoti bilan matlubdir. Haqiqatan ham u barcha narsadan lazzatli. Ilmdan boshqa qanday narsada manfaat zohirroq va qandayida foyda ko'proq bo'ladi, faqat ilm bilangina ham din, ham dunyo uchun xayrli ishlarni qilish va ularga zarar keltirishdan saqlanish mumkin. Agar ilm bo'lmaganida, biz jalb qilayotgan narsa yomonlik emasligiga va chetlanayotgan narsa yaxshilik emasligiga ishonch bo'lmas edi."

Beruniyning bu ibratomuz so'zlarini oradan to'rt asr o'tib, Mirzo Ulug'bek ham takrorlaydi. U yozadi: "Ilmdan boshqa hayot yo'q va bo'lishi mumkin ham emas." Ulug'bek so'zlaridagi "ilm" va "hayot" so'zlarini o'zaro yonma-yon ishlatilib, bir-biriga ma'nodosh so'zlar sifatida istifoda qilinishiga e'tibor bering. Bundan kelib chiqadiki, ulug' olim ilm deganda hayotni, hayot deganda esa ilmni tushungan va nihoyatda oqilona tushungan. Chindan ham, tiriklik, umr, yashamoq deb atalmish buyuk mo'jizaning har bir zarrasi, unsuri, atomi, hujayrasi, neyroni boshdan-oyoq ilm emasmi? Ehtimol, Ulug'bekni falakiyot ilmini chuqurroq o'rganishiga va murakkab astronomik jadvallar tuzishiga ana shunday erkin, nostandart fikrlari turtki bergandir?

Afsuski, Farg'oniy haqidagi biografik ma'lumotlar

saqlanib qolmagan, shunga ko'ra hayoti va ijodiy faoliyatining ko'pgina qirralari taxmin qilinadi. Biroq uning "Xosib", "Munajjim ar-Rais" degan unvonlarga sazovor bo'lgani hamda astronomiya, astrometriya, matematika, geografiya, geodeziya, gidravlika, geometriya va boshqa fan sohalariga beqiyos hissa qo'shgani ko'pgina ishonchli manbalarda yozib qoldirilgan. Ayniqsa, uning "Astronomiya ilmi" asarida yunon olimi Ptolomey g'oyalari rivojlantirilgan bo'lib, ilmiy dalillangan argumentlar kiritilgan hamda tamoman yangi, original ilmiy fikr va qarashlar bayon qilingan. Asarning uchinchi bobida Farg'oniy tomonidan Yerning shar shaklida ekanligi birinchi marta to'laqonli tarzda ilmiy isbotlab berilgan bo'lib, bu isbot hozirgi fan beqiyos rivojlangan asrimizda ham o'z qimmatini va mantig'ini yo'qotgan emas.

Farg'ona madaniy-ma'naviy muhitidan yetishib chiqqan buyuk bobokalonimiz va uning ilmiy-ijodiy merosi xususida kengroq to'xtalayotganimizning boisi shuki, biz katta maqsad va niyatlar bilan to'ng'ich elektron jurnalimizni "Ahmad al-Farg'oniy avlodlari" degan ramziy nom bilan atadik va Yurtboshimiz ta'kidlaganidek talaba-yoshlarimiz orasidan shunday ulug' insonlar yetishib chiqishini orzu qildik.

Yangi elektron jurnalning katta hayotga yo'llanma olishi, bugungi kunda hammamizga yaxshi ma'lumki, juda katta, olamshumul voqea hisoblanmaydi. Respublikamiz oliy o'quv yurtlarida ham, xususiy yo'nalishlarda ham elektron jurnallar barpo etishga hech qanday to'siq yo'q va ular an'anaviy tarzda chop etilayotgan ilmiy jurnallar bilan erkin raqobat qilgan holda faoliyat yuritmoqda. Maqsad bitta – ilm-fan sarhadlari kengaysin, ilm egallashga rag'bat kuchaysin, ilmiy-tadqiqotlar sifati yanada mukammallik kasb etsin. Ta'lim sifatini yuksaltirishga intilish ham ilm-fan rivojlanishiga kuchli ta'sir etishiga shak-shubha yo'q.

Zero 2023 yilni "Insonga e'tibor va sifatli ta'lim yili" deb e'lon qilinishining bosh sabablaridan biri ham ana shundadir.

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RAQAMLI IQTISODIYOT SEKTORINI RIVOJLANTIRISHDA MAHALLIY XUSUSIYATLAR ASOSIDA TADQIQ QILISH

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Maqolada raqamli iqtisodiyot tushunchalari va uning mahalliy xususiyatlari tahlili haqida so'z boradi. Mamlakatimizning raqamli iqtisodiyot sektorini rivojlanishi, elektron tijorat, onlayn savdo yo'nalishlarida amalga oshirilayotgan ishlar va unga ta'sir etuvchi omillar haqida ma'lumotlar keltirilgan.

Kalit so'zlar. raqamli iqtisodiyot, elektron tijorat, CRM, feedback, to'lov, internet, tranzaksiya

Kirish. Raqamli iqtisodiyot – bu iqtisodiy, ijtimoiy va madaniy aloqalarni raqamli texnologiyalarni qo'llash asosida amalga oshirish tizimidir. Ba'zida u internet iqtisodiyoti, yangi iqtisodiyot yoki veb-iqtisodiyot degan terminlar bilan ham ifodalanadi.

1995 yilda amerikalik dasturchi Nikolas Negroponte "raqamli iqtisodiyot" terminini amaliyotga kiritdi. Hozirda bu istilohni butun dunyodagi siyosatchilar, iqtisodchilar, jurnalistlar, tadbirkorlar – deyarli barcha qo'llamoqda. 2016 yilda Butunjahon banki dunyodagi raqamli iqtisodiyotning ahvoli haqida ilk marta ma'ruza e'lon qildi.

Mamlakatimizda raqamli iqtisodiyotni faol rivojlantirish, barcha tarmoqlar va sohalarda, eng avvalo, davlat boshqaruvi, ta'lim, sog'liqni saqlash va qishloq xo'jaligida zamonaviy axborot-kommunikatsiya texnologiyalarini keng joriy etish bo'yicha kompleks chora-tadbirlar amalga oshirilmoqda.

Xususan, elektron hukumat tizimini takomillashtirish, dasturiy mahsulotlar va axborot texnologiyalarining mahalliy bozorini yanada rivojlantirish, respublikaning barcha hududlarida IT-parklarni tashkil etish, shuningdek, sohani malakali kadrlar bilan ta'minlashni ko'zda tutuvchi 220 dan ortiq ustuvor loyihalarni amalga oshirish boshlangan.[1]

Raqamli iqtisodiyotning oddiy iqtisodiyotdan farqi nimada? Masalan, xaridorga poyafzal kerak. Uni bozorga tushib o'zi bevosita tanlasa va naqd pulga sotib olsa, bu an'anaviy iqtisod. Telegramdagi biron savdo boti orqali o'ziga ma'qul tovarni tanlab, tovar egasiga pulni elektron to'lov tizimi orqali to'lash va tovarni yetkazib berish xizmati orqali olish – raqamli iqtisodiyot deyiladi. Bu masalani eng sodda maishiy misol orqali tushuntirishdir. Aslida, hammamiz allaqachon raqamli iqtisodiyot ichidamiz, uning qulayliklaridan foydalanamiz. Masalan, oyliklarimiz plastik kartalarga tushadi, elektron to'lov orqali kommunal xizmatlar, telefon, internet va boshqa mahsulot va xizmatlarga to'lov qilamiz, elektron tarzda soliq deklaratsiyasi topshiramiz, kartadan kartaga pul uzatamiz, uyga taom buyurtma qilamiz va hokazo.

Raqamli iqtisodiyot – bu noldan boshlab yaratilishi lozim bo'lgan qandaydir boshqacha iqtisodiyot emas. Bu yangi texnologiyalar, platformalar va biznes modellar yaratish va ularni kundalik hayotga joriy etish orqali mavjud iqtisodiyotni yangicha tizimga ko'chirish deganidir.

Belgilari:

- yuqori darajada avtomatlashtirilganlik;

- elektron hujjat almashinuvi;

- buxgalterlik va boshqaruv tizimlarining elektron integratsiyalashuvi;

- ma'lumotlar elektron bazalari;

- CRM (mijozlar bilan o'zaro munosabat tizimi) mavjudligi;

- korporativ tarmoqlar.

Qulayliklari:

- 1. To'lovlar uchun xarajatlar kamayadi (masalan, bankka borish uchun yo'lkira va boshqa resurslar tejaladi).

- 2. Tovarlar va xizmatlar haqida ko'proq va tezroq ma'lumot olinadi.

- 3. Raqamli dunyodagi tovar va xizmatlarning jahon bozoriga chiqish imkoniyatlari katta.

- 4. Fidbek (iste'molchi fikri)ni tez olish hisobiga

tovar va xizmatlar jadal takomillashtiriladi.

- 5. Tezroq, sifatliroq, qulayroq.

Adabiyotlar tahlili. Raqamli platformalarning rivojlanish sohasidagi yorqin misollardan biri sifatida "Alibaba" elektron savdo tizimiga ega bo'lgan Xitoy kompaniyasini keltirib o'tish mumkin. Undan foydalanish tajribasi shuni ko'rsatadiki, ma'lumotlar to'plash jarayonida iqtisodiyotning turli sektorlariga ekspansiya uchun o'ta raqobatli ustunliklar yaratiladi. "Alibaba" bu – oddiygina raqamli platforma emas, balki platformalar ekotizimidir. Better Than Cash Alliance moliyaviy tahlillari shuni ko'rsatadiki, Alipay 2016 yilda 1,7 trillion dollar tranzaksiyalarni o'tkazgan, bu 2012 yildagi atigi 70 milliard dollardan kam. Keyingi 10 yil ichida Alipay o'zining foydalanuvchi bazasini hozirgi 450 milliondan (2016 yil ma'lumotlari) 2 milliardga oshirishni rejalashtirmoqda.[2]

Raqamli iqtisodiyotning eng faol drayveri – bu davlatdir. U raqamli iqtisodiyotning asosiy buyurtmachisi va iste'molchisidir. Masalan, Xitoy bu maqsadlar uchun 9 milliard dollar atrofida mablag' sarflagan. Bozor kapitalizatsiyasi 210 milliard dollardan ziyod bo'lgan Alibaba internet resursi ushbu sarmoyalarning to'g'ri yo'naltirilganini isbotladi.[3]

Raqamli iqtisodiyot insonlarning turmush darajasini sezilarli darajada oshiradi, bu uning asosiy foydasidir. Raqamli iqtisodiyot korrupsiya va "qora iqtisodiyot"ning asosiy kushandasidir. Chunki, raqamlar hamma narsani muhrlaydi, xotirada saqlaydi, kerak paytda ma'lumotlarni tez taqdim etadi. Bunday sharoitda biron ma'lumotni yashirish, yashirin bitimlar tuzish, u yoki bu faoliyat haqida to'liq axborot bermaslikning iloji yo'q, kompyuter hammasini namoyon qilib qo'yadi. Ma'lumotlar ko'pligi va tizimliligi yolg'on va qing'ir ishlarga yo'l bermaydi, chunki tizimni aldash imkonsiz. Natijada "iflos pullarni" yuvish, mablag'larni o'g'irlash, samarasiz va maqsadsiz sarflash, oshirib yo yashirib ko'rsatish imkoni qolmaydi. Bu esa iqtisodiyotga legal mablag'lar oqimini oshiradi, soliqlar o'z vaqtida va to'g'ri to'lanadi, byudjet taqsimoti ochiq bo'ladi, ijtimoiy sohaga yo'naltirilgan mablag'lar o'g'irlanmaydi, maktablar, kasalxonalar, yo'llarga ajratilgan pullar to'liq yetib boradi va hokazo.

Raqamli iqtisodiyot bu ishlab chiqarish kompleksi insonlar uchun qulayliklarni ta'minlaydigan mahsulot va xizmatlarni yaratadigan virtual muhit bo'lib, raqamli texnologiyalardan foydalangan holda iqtisodiy ishlab chiqarish tizimidir. Shuningdek, raqamli iqtisod rasmiylashtirilishi mumkin bo'lgan barcha narsani qamrab olishi mumkin, ya'ni mantiqiy sxemalarda namoyon bo'ladi. Hayotning o'zi esa bu «narsalarni» ishlab chiqarish, tarqatish, almashtirish va iste'mol qilish tizimiga aylantirishga imkoniyat yaratadi. Haqiqatdan ham insonning ongidagi haqiqatida joylashgan dunyoning virtual qismidan oldin ishlab chiqarish kuchi bo'lmagan, yangi g'oyalar va mahsulotlar yaratilgan muhit emas edi.[4]

Davlatning raqamli iqtisodiyotni rivojlantirish yo'lini tanlaganligi axborot texnologiyalari sohasida va umuman, elektron hujjatlar aylanmasi sohasida yangi yo'nalishlar ochib beradi. "Raqamli texnologiyalar" tomon burilishga butun jahon internet tarmog'i va sifatli aloqaning rivojlanishi sababchi bo'ldi.

"Raqamli iqtisodiyot" tushunchasi ko'pincha to'rtinchi sanoat inqilobiga o'tish jarayoni sifatida, ilmiy doiralarda to'rtinchi sanoat inqilobi (sanoat 4.0) haqidagi g'oyalar shakllana boshlagan paytda qo'llaniladi. So'nggi inqilob kiber-fizik tizimlarni joriy etish orqali ishlab chiqarishning yangi turini o'z ichiga oladi.[5]

Jahon banki ma'lumotlariga ko'ra, jami 80 mamlakat va hududlar "yuqori daromadli mamlakatlar" toifasiga kiritilgan. 2022-moliyaviy yil holatiga ko'ra, yuqori daromadli mamlakatlarda aholi jon boshiga yalpi ichki mahsulot 12 696 AQSH dollarini tashkil qilgan.Shuning uchun ushbu maqolaning nazariy taxmini ko'proq daromadi past bo'lgan mamlakatlarga taalluqlidir.[6]

O'zbekistonda raqamli iqtisodiyot qay darajada rivojlangan? Ta'kidlash joizki, bugungi kunda foydalanuvchilar oziq-ovqat mahsulotlariga buyurtma berish uchun Telegram botlaridan faol foydalanmoqdalar. Shuningdek, turli internet do'konlar, elektron to'lov tizimlari ham faol rivojlanib bormoqda. Demak, fuqarolarimiz elektron bitimlarni amalga oshirishga ishonyaptilar. Faqat hozirgi kungacha foydalanuvchilar katta xarajatlar talab qilmaydigan kichik bitimlarni amalga oshirmoqdalar, o'rtacha xarid hajmini oshirishga esa unchalik tayyor emaslar. Endigi masala o'rtacha va yirik iqtisodiy bitimlar va moliyaviy operatsiyalarni
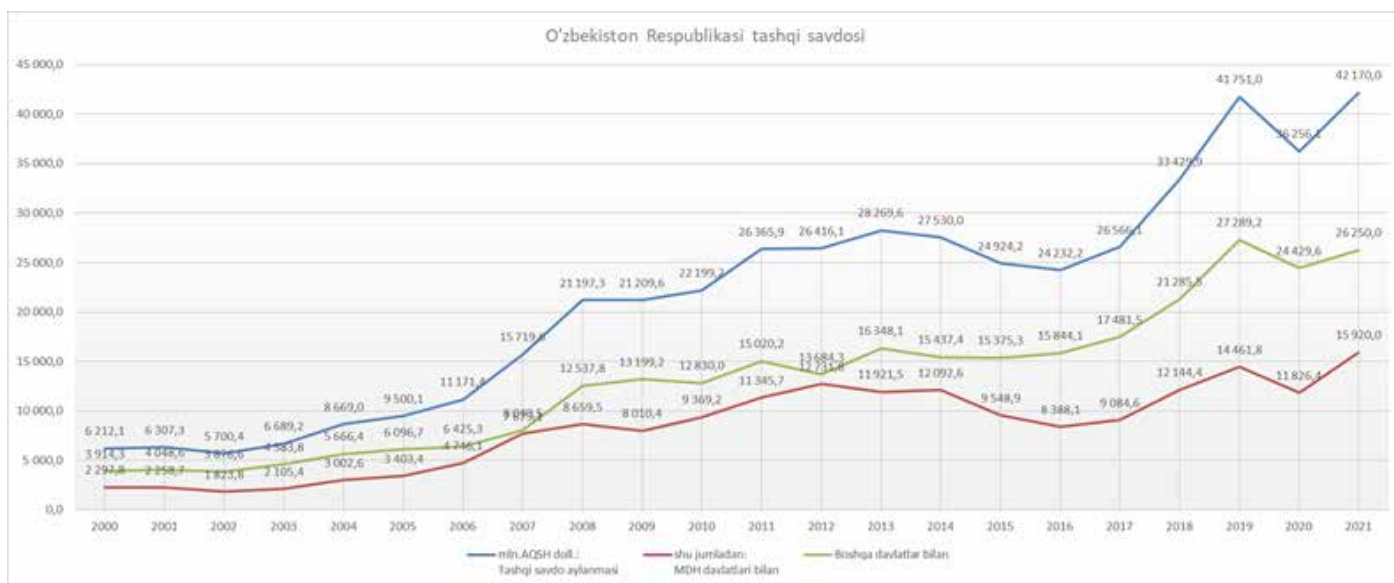
Diagramma 1. O'zbekiston Respublikasi tashqi savdosi.

raqamli texnologiyalar orqali amalga oshirishni rivojlantirishdan iborat.

Natijalar. Dunyo tajribasini o'rganish natijasida shu narsa ma'lum bo'ldiki, raqamli iqtisodiyoti rivojlangan mamlakatlarda raqamli iqtisodiyotda hukumat bozor "o'yin" qoidalarini o'yinning barcha ishtirokchilari uchun belgilaydi va bunda davlatning eng muhim vazifasi sifatida o'yin ishtirokchilari uchun bir xil, teng huquqli va imkoniyatli sharoit yaratib berish hisoblanadi. Ya'ni, bozorda katta kompaniya bo'ladimi yoki kichik biznes, ular teng huquqli hisoblanadi. Ularga bir xil imkoniyatlar beriladi. Davlat qoidalarga amal qilinishi va oxir oqibatda oddiy iste'molchi sifatli, zamonaviy xizmat yoki mahsulot olishi ta'minlanadi. Demak, raqamli iqtisodiyot rivojlanishi uchun davlat hamma uchun teng sharoit yaratib berishi, iloji boricha bozor qoidalari, qonunlar, shartnomalar shaffof bo'lishi, qonunlar bozor talabidan kelib chiqqan holda, ya'ni bozordagi rivojlanish tendensiyalarini oldindan aniqlay olishi va kerakli normativ hujjatlarni qabul qilishi, o'yin ishtirokchilari uchun erkinlik berishi zarur.

Dunyo mamlakatlari kabi mamlakatimizda ham
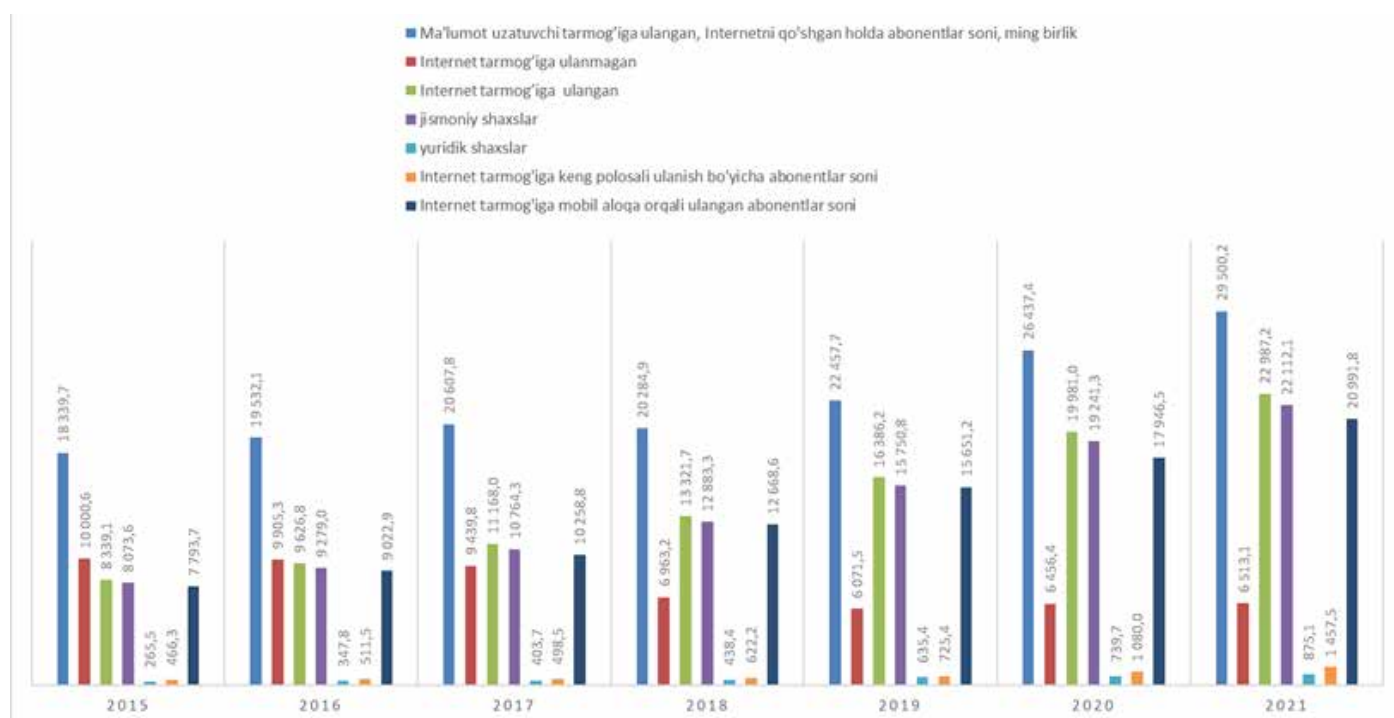
Diagramma 2. Ma'lumotlar uzatish tarmog'i ko'rsatkichlari

raqamli iqtisodiyot kun sayin rivojlanib bormoqda. Kundalik hayotimizga axborot texnologiyalarni tatbiq qilinishi oddiy insonlar uchun ko'plab qulayliklar yaratmoqda. Uydan chiqmasdan ko'plab oziq-ovqat mahsulotlari va taomlariga buyurtma berishimiz, ularni uyimizgacha yetkazib berishlari mumkin bo'lmoqda.

O'zbekiston Respublikasi Prezidenti huzuridagi statistika agentligi ma'lumotlariga ko'ra, O'zbekiston Respublikasi tashqi savdo aylanmasi boshqa davlatlarga nisbatan MDH davlatlari o'rtasida yuqori ko'rsatkichlarni ko'rsatmoqda(diagramma 1). Natijalar yillar kesimida ko'rsatilgan.

Lekin shuni ta'kidlash kerak-ki, O'zbekistonda raqamli iqtisodiyot O'zbekiston potensialiga nisbatan bir necha barobar sekinroq rivojlanmoda. Ya'ni imkoniyat bor, kerakli resurslar mavjud lekin rivojlanish ancha sust. Bunga sabab sifatida raqamli iqtisodiyotni O'zbekistonda rivojlanishini bir qancha to'siqlarini ko'rsatib o'tish mumkin.

- ko'plab sohalardagi monopoliya;
- internet tezligini pastligi va uni sifatsizligi;
- axborot texnologiyalari sohasida qonununchilikning zamondan orqada qolganligi;
- fuqarolarda kompyuter savodxonligining o'ta pastligi;
- qonunchilikning shaffof emasligi;
- axborot texnologiylari bo'yicha mutaxassislarning yetishmasligi yoki ularni boshqa mamlakatlarga ketib qolishi;
- axborot madaniyati, axborot gigiyenasi pastligi;
- axborot texnologiyalari xavfsizligi yaxshi emasligi;
- boshqaruv organlarida sohani tushunadigan mutaxassislarning kamligi yoki(ba'zilarida) ularning umuman yo'qligi;
- ilm-fan va ayniqsa aniq fanlarning rivojlanishi sustligi(yoki rivojlanishdan to'xtab qolganligi).

Respublikamizda so'nggi yillarda internet tarmog'iga foydalanuvchilarni ulash bo'yicha faol harakatlar amalga oshirilayotgan bo'lsada, lekin raqamli iqtisodiyotning elektron tijorat, onlayn savdo qismini rivojlantirish uchun yetarli natijalarga erishish uchun kamlik qilmoqda. Raqamlarga qaraydigan bo'lsak, internet tarmog'iga keng polosali ulanish bo'yicha abonentlar soniga nisbatan, mobil aloqa orqali ulangan abonentlar soni ko'proqni tashkil qiladi. Mobil qurilma orqali internetga ulanishda esa hamisha ham sifat yuqori deb bo'lmaydi.

O'zbekiston aholisi 2020 yil holatiga Davlat statistika qo'mitasi ma'lumotiga ko'ra, 34 mln. atrofida bo'lgan. Internetdan foydalanuvchi aholi soni esa o'sha yil holatiga 22 mln. odamni tashkil etgan. Shundan 19 mln. foydalanuvchi mobil qurilmalar orqali internetdan foydalangan.[7] Raqamlardan ko'rinib turibdiki, mamlakatimizda mobil qurilmalar orqali internetdan foydalanish ancha faol hisoblanadi.

Xulosa. Elektron tijorat sohasida IT-mutaxassislar sonini ko'paytirish maqsadida, 2018-yilda Muhammad al-Xorazmiy nomidagi Toshkent axborot texnologiyalari universitetida elektron tijorat yo'nalishi ochildi. 2020-2022 yillarda hukumat elektron tijoratning o'sishini tezlashtirish uchun bir qator muhim qadamlarni qo'ydi. Unga ko'ra:

- 2020-yil oktabr oyida "Raqamli O'zbekiston – 2030" strategiyasining qabul qilinishi: Hukumat butun mamlakat bo'ylab qurilgan optik tolali aloqa tarmog'i uzunligini hozirgi 118 000 kilometrdan (73 322 milya) 250 000 kilometrga (155 343 milya) ga oshirishni rejalashtirmoqda; 2030 – yilga borib yuqori tezlikdagi internet qamrovini hozirgi 67 foizdan 100 foizgacha oshirish; mobil keng polosali qamrovni 2022 – yilga kelib hozirgi 78 foizdan 100 foizgacha kengaytirish; axborot texnologiyalari yo'nalishi bo'yicha oliy va o'rta maxsus ta'lim muassasalariga o'qishga qabul qilish uchun yillik kvotalar miqdorini

- 2030 – yilgacha amaldagi 7 ming nafardan 20 ming nafargacha oshirish vazifalari ustuvor vazifalar etib belgilangan. O'zbekiston 2021-2022-yillarda raqamli infratuzilmani rivojlantirishga 2,5 milliard dollar sarmoya kiritish rejasini ma'lum qildi.

- O'zbekiston Eksportni qo'llab-quvvatlash agentligi Xitoyning Alibaba elektron tijorat kompaniyasi bilan hamkorlikda 2020-yil oktabr oyida Alibaba.com platformasida "O'zbekistonda ishlab chiqarilgan" bo'limini yaratdi va unda tanlangan mahalliy kompaniyalar mahsulotlari namoyish etiladi; hukumat Alibaba.com platformasida 300 dan ortiq mahalliy kompaniyalarni ro'yxatdan o'tkazish uchun moliyaviy yordam ko'rsatishni rejalashtirmoqda.

Yuqorida keltirilgan muommolar bosqicha-bosqich, tizimli, dunyo tajribasidan kelib chiqib hal qilinsa, O'zbekiston ham bemalol raqamli iqtisodiyoti rivojlangan mamlakatlarda biri bo'la oladi.

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MODELING OF PROCESSES OF OIL REFINING UNDER OPERATIONAL MANAGEMENT ON INDICATORS OF QUALITY OF PRODUCTS

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Abstract: The main feature of oil refining industries is the instability of the characteristics of raw materials and the multi-assortment of products. At the same time, the processing mode is largely determined by the characteristics of the raw materials and the task for the production of products.

Keywords: oil, raw materials, plant, types of oil products, oil processing

Introduction. The main feature of oil refineries is the instability of the characteristics of raw materials and the multi-assortment of products. At the same time, the processing mode is largely determined by the characteristics of the raw materials and the task for the production of products. Due to the fact theat it is not possible to quickly analyze the composition of raw materials and calculate them by determining the parameters of technological regimes, oil refining is usually managed withe large margins in terms of quality indicators.

The purpose of operational management is to ensure the maximum yield of products of a given quality from the raw materials entering the plant, minimizing energy and material costs, i.e. ensuring optimal performance indicators (PE) of the process. The information on the basis of which the formation of control actions is carried out is: restrictions on the values of the parameters of the technological regime, the values of the normalized indicators of the quality of products and the PE of the process.

In practice, the way to obtain the values of quality indicators (QI) of products is to conduct laboratory analyzes of wiped samples. The frequency and time spent on laboratory analyzes withe such an organization of the information subsystem do not provide the possibility of operational management and maintenance of high PE.

The combination of raw materials withe unstable characteristics and the lack of operational information about the PC of the products obtained are the main factors theta make the task of selecting a technological mode extremely difficult. Theas. obtaining high process efficiency carriers is difficult, including due to the lack of high-quality operational information about the process. The main difficulty in promptly obtaining information about the PC is due to the lack (or extreme limitations) of quality control tools for oil refining products on stream.

The solution of the problem of operational estimation of the values of the PC of all the products involved in the process, as studies show, makes it possible to increase the efficiency of production from several to two tens of percent.

The simplest and most easily implemented way to obtain information about the PC is to calculate the required indicators for models.

The task of process control is the choice of such a technological regime, in which, under the conditions of technological limitations. the action of various kinds of disturbances (controlled and uncontrolled), the change of production tasks for the production of products, the maximum yield of the target product of a given quality is ensured at minimum energy costs, which characterizes the optimal PE of the process.

All PEs of the control system can be evaluated on a rank scale, when the rank is determined by the complexity of the operational evaluation and optimization of these indicators. At the same time, a special place in the calculation and provision of optimal technical and economic indicators (the global goal of management) is given to maintaining the

specified technical so far, in particular, the PC of the products obtained. [2]

One of the main features of the processes of oil refining and petro chemistry is the great dependence of the PC of products n II") of production on the characteristics of the feedstock entering the plant. The instability of the characteristics of raw materials determines the need to change the regime parameters in order to maintain the normalized PC of the products obtained.

In the operational management of processes for PE and PC products, problems arise, first of all, in the development of the information part of the control system. Theism is due to the following reasons: 1) some process parameters are practically not amenable to accurate quantitative analysis (for example, the characteristics of petroleum feedstock), therefore, there is usually no operational ("on-stream") information about the feedstock; 2) there is no possible and operational determination of the value PC of the resulting product", which does not allow organizing feedback on the final result of production.

The following should be attributed to the problems of control subsystems in process control by PC: 1) the absence of an explicit and uniform connection between technological parameters and PC of commercial products, which determines the ambiguity of the choice of control actions; 2) The presence of a large number of restrictions on the parameters of the technological mode and PC products; 3) Limited control resources: a typical situation is when there are fewer control parameters than controllable coordinates; 4) multi-criteria of the control task: when managing the PC of products, it is required to maintain a number of PCs of one (several) oil products.

Theas, under the conditions of frequent uncontrolled change of raw materials, fundamental or technical unfeasibility of measuring the majority of PE and PC, the complexity of the control task, the existing methods of building systems do not provide control efficiency. In this regard, when managing oil refining processes, the efficient use of material and energy resources and the specified process PEs are not ensured.

The analysis of ways to solve the problem of control optimization revealed, as one of the main tasks, the need to obtain operational information about PC products. Based on the foregoing, the main task of the study is considered - the principles of building

and functioning of the information subsystem of PC products for the purposes of operational management.

Based on the analysis of methods for the rapid production of PC products, it was determined theta often the only acceptable method is to determine them on the basis of indirect measurement, i.e. the calculation is indicative of the models. To calculate the PC from the models, a situational approach to modeling processes is used, which makes it possible to reduce the number of input parameters of the models, simplify the structure and procedures for identifying the coefficients of the PC models.

The task of evaluating a PC product" by situational models was divided into two subtasks: 1) determining the structure and parameters of models theta are adequate to the object. in a given area of variation of technological parameters; 2) separation of areas of adequacy of such models.

In addition, the task of training situational models is also relevant, i.e. formation of a knowledge base in the form of situational models calculation of PC products based on observations of a real object.

the development of situational models for calculating the PC of products involves the use of methods for identifying a technological situation in order to select an appropriate situational model. The paper deals with the problem of identifying a technological situation determined by the set R of input parameters, the set T of technological parameters, and restrictions on the quality of the product. Under the i - and technological situation we mean theta the current parameters from R and T belong to a certain subset $g_1, g_1 \in R \cap T i = 1, 2.............$

For oil refining processes, often not all of the indicative variables through which situations are set can be set or quickly measured, for example, the characteristics of petroleum feedstock, catalyst activity, and the so-called. (elements of the set R). In this regard, the tasks of identifying the technological situation into dependent and initial data are formulated in two settings: 1) non-measurable process parameters are set as initial information; 2) some elements of the set R are a priori unknown. [3]

In the first case, the identification of the technological situation is proposed to be carried out on the basis of the analysis of logical expressions. To do this, at first, the interval of permissible changes in each attribute variable x_1 is divided into $к\_1$, subinterval in . for

each sub-singer, a Boolean variable is placed in the outer corner

$$S_{k_i} = \begin{cases} 1 x_1 \in x_{k_i} \\ 0 x_1 \notin x_{k_i} \end{cases} i = \ln . k = 1.2....$$

Then the situations can be identified based on the analysis of logical expressions $Q_p j = l.N_c$ where

$N_c = \prod_{i=1}^{n} m_i$ - the number of situations introduced into consideration, composed of variables S_{k_i} and their negations $i = l.n : k_1 = l.m_1, m_1$ - the number of situational subintervals of the variable) ;

the measured value of one attribute variable is equal to the boundary value (boundary situation of the first type);

the measured values of two attribute variables are equal to the boundary ones (boundary situation of the second type), etc.

In the general case, for n feature variables it is possible to distinguish n gnostic boundary situations. In addition, for any number n of feature variables, the boundary of the n -the type will be expressed by a point, the boundary of (n-1) type - by a straight line, (n -2)-the type - by a plane. The remaining boundary situations of a lower order will be characterized by some hyperplane.

In the first case, the situation can be uniquely identified, but since the situational model was obtained for the central values of the situational subintervals, then for the current situation it is possible and reasonable to correct the estimated values of the PC based on the consideration of the membership function of the base case. In addition, the ego provides a seamless evaluation of the PC when moving from one situation to another.

For the second case, it is necessary to correct the PC values for two situational models, for the third - for four, for the fourth - for eight, etc.

The measure of belonging of the observed situation to the basic options is estimated on the basis of logical expressions Q_1

evaluation method is reduced to the following sequential steps: 1) Q_1 conjuncts theta are inversions are excluded from the records S_{k_i}, 2) Boolean variables S_{k_i} (I) are assigned fuzzy variables withe S_{k_i} membership functions U S_{k_i} (1), having a

maximum at the center of the subinterval K_13) two-valued logic operations are put in correspondence with fuzzy logic operations. Then the values of the output symbol $\tilde{Q}_j (j = l.N_c)$ can be considered as a function of membership of the current situation in the j -the base case.

The correction value is defined as

$$a_1 = \tilde{Q}_j / \sum_{r=l}^{N_c} \tilde{Q}_R \qquad (2)$$

where, a_1is the weight coefficient withe which the calculated value of the PC, obtained from the j -the situational model, will enter the corrected value

$$B^x = \sum_{j=l}^{N_c} B^{Mj} . a_j \qquad (3)$$

where is B_j^Mthe set of PC values determined by the j -the situational model for calculating PC products.

The disadvantage of the proposed correction metheod is the need to synthesize and calculate Nc logical expressions.

To reduce the amount of calculation, the following procedure is proposed.

Variables S_{k_i} for which U(S_{k_i}) $\neq 0$ form the set

$$\tilde{S} = \{ S^r_{k_i} \} . r = l.R : R = \sum_{i=l}^{n} p_1 \text{ "P value, for each}$$

feature variable x_1, equal to v_1, - the number of subintervals U(S_{k_i}) $\neq 0$. except when the value of the feature variable x_1is in the intervals $\left[x_1^R : x_1^0 \right]$ or

$$\tilde{S} = \{ \tilde{S}^r_{k_1} \} . r = I.R : R = \sum_{i=1}^{n} p_1 \text{ the lower and upper}$$

limits of the interval of variation of the variable are x_1the variation of the variable x_1in the cither of the first and last sub-intervals Then the value $p_1 = v_1 - I$ is allocated a subset of logical expressions

$$Q_G = \{ Q_1 \}, j = I, q : q = \prod_{i=l}^{n} p_1 \bullet \text{ coo corresponding to}$$

boundary situations . To derive a subset Q_G; fuzzy set S is associated withe a set S , whose elements are logical units. The set Q_Gis formed by a complete enumeration of combinations. $S_{k_i} \in S$ According to the metheod proposed above for assessing the belonging of the observed situation to the basic options for the ones selected at the previous step, Q_ Gfuzzy logical expressions are synthesized $\tilde{Q}_j j = I, q,$

and the value of PC is corrected but (2) and (3). Obviously, $q \le N_c$ the type of the boundary situation is determined on the basis of the calculated Qj

$$t = \ln N / \ln 2, \qquad (4)$$

where N is the number of fuzzy logical expressions withe the same (up to rounding errors) values.

The paper explores the possibility of correcting the calculation of the PC for situational models based on the calculation of known types of measure (distance) or current to basic situations. It is shown that this approach is more laborious and contains a large number of subjective operations, such as justifying the type of measure, the method of normalizing distances. It is advisable to use a correction based on the calculation of the distance if the cumulative influence of all variants of basic situations is estimated for the corresponding types of membership functions of attribute variables.

The method of identification characterizes the ease of implementation. At the same time, it is possible to identify the situation only in the class of measured parameters of the technological mode, which is a rather strong limitation on the use of the above methods for identifying the mode of oil refining and petro chemistry processes. Therefore, it is very important to develop approaches to solving the problems of identifying a technological situation also in the presence of unmeasured process variables, in particular, the characteristics of raw materials.

Aggregate $R \cap U$ generates a set of indicative variables P, which determine the technological situation. Significant variables named differently in interdependence withe the process, or a different rush is also important for characterizing the situation. Therefore, the whole set P can be divided into subsets p where it will determine the priority of the group of attribute variables no to the criterion of reparability of the situation, we will take a tuple of subsets p_1,p_2... establishes a rank scale for measuring these priorities.

Theus, the task of identifying a situation and choosing a situational model is divided into subtasks: I) assessing whether current parameters belong to $t^0, r^0, r^0, \in R \ t^0, \in T$ one of the subsets G_12) choosing a model from among the situational models corresponding to the $g_1^j \in G$ The first task of identification requires a solution if the subset G_1, is not directly defined through the initial information, E e solution is associated with the definition of trying on

features n_1, subset P_1-

It is proposed to determine the parameters of a subset p_1based on the mapping

$$\psi\{R,T\} \xrightarrow{J_1} G_1(\eta_1), \qquad (5)$$

here is J_1the corresponding criterion, by which, from the set of $\psi\{\bullet\}$ signs formed by the operator are uniquely distinguished G_1.

The definition of the subset g , J was also proposed to be carried out on the basis of the operator $\psi\{\bullet\}$, but already in the subset Gj

$$\psi\{r_1 t_1\} \xrightarrow{J_2} g_1^j \qquad (6)$$

Here - corresponding criterion, which is J_2uniquely distinguished g_1from the set of $\psi\{\bullet\}$ features formed by the operator G_1. Theus, the task of identifying a technological situation is ¬considered as a multi-criteria two-stage decision-making procedure.

The convergence of the decision-making procedure is evaluated by the criterion

$$J = \Omega\{g_i^1\} - \eta \to 0 \qquad (7)$$

where the index n_1is determined by (5); $\Omega\{*\}$ - some operator

As a mapping model $\psi\{\bullet\}$ for identifying the modes of distillation processes, it is proposed to use the model for calculating the characteristic points of the PC (PC side extractions) $t_i^a = f(R,l)$, where t_i^a t e apparat yapp drinking and % of the i -the selection, u = 10.90 "% coo corresponding to one of the selected situations, for example, M 1.

Our studies have shown that outside the area of adequacy of situational models for the processes of separation of oil c m e withe e the rectification methods, there is an unambiguous relationship between the input coordinates of the model R and T and the calculated one t_i^a . are functionally related to the measured R and T, and are also unchanged by the parameters of the set R .

Applying the procedure for restoring the ITC curve of raw materials from points calculated by M 1, you can get a lot of curves, the position of which will be determined by bothe external factors, such as the type of raw materials, and the parameters of the technological regime. At the same time, the functional relationship between the parish of the model t_i^a and the process parameters R and T is clearly traced. The

resulting curve will be called the pseudo-ITC curve of the raw material r (r ", t "). The raw PTC curve is an auxiliary model designed to determine the measured parameter - the type of raw material.

On fig. I shows the pseudo-ITC curves obtained using the display model for some modes Cap corresponds to the pseudo-ITC curve for the type of raw material - a mixture of Tuymaznskaya and West Siberian low-sulfur oil 50% / 50%; (•) corresponds to the pseudo-ITC curve for the type of raw material - pure 'West Siberian sweet oil).
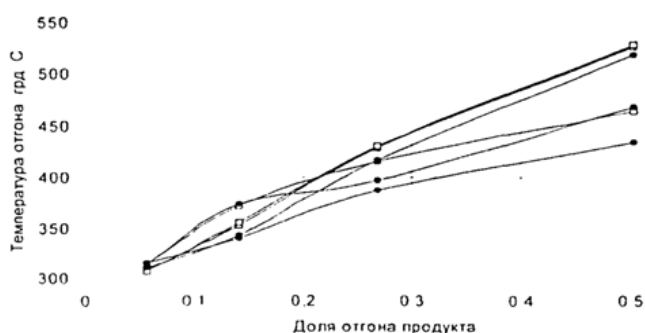
Figure 1. Pseudo-ITC curves of raw materials reconstructed from an auxiliary model

Studies have shown that for a given raw material at various operating parameters, the pseudo-ITC curves form a bundle of curves, the boundaries of which will not coincide withe the boundaries of the bundle of curves corresponding to another raw material in the sense of the J criterion. Theus, the task of identifying a technological situation through pseudo- ITC curves is equivalent to the pattern recognition problem. Moreover, the first subtask of identification of the subset G, is reduced to the beam of curves corresponding to the attribute; n_1 $n_1 \in p_1$ the second subtask of identification $g_1 \in G_1$ is defined as the flow of the corresponding curve in this beam.

Identifying a technological situation based on pseudo-ITC curves withe different levels of information about the unchanging process variables are considered, and various criteria for (6) and (7) are proposed. The identification procedure has the form.

Step 1. Subset G_1and situation are identified $g_1^i, g_1^i \in G_1 (i = l, n_c; j = l, m; n_c)$ - the number of subsets introduced into consideration, divided by non- measurable process parameters (situation in subset p|); m is the number of selected situations in the rank of one immutable feature).

Step 2. Restore feature η_1 by subset ρ_1 using feature

properties $g_1 \in G_1$

Step 3. If the feature η_1, matches the feature defined in step I, then the subset G_1, is identified correctly. Otherwise, the situation is considered in the subset $G_1 (l \neq i)$ If, after enumeration of the entire subset p, no match was found for the features identified at various stages, n_1the following options for completing the procedure are possible:

patterns are estimated on the basis of sensitivities, with the involvement of information about the "proximity" of the current regime to the selected subsets , if there are mechanisms for adapting models, additional subsets G_1G are allocated , and the corresponding models M'

The development of a feature verification procedure n_1(step 2) requires an individual -approach to individual petroleum refining processes and elements of the p3 subset . In particular, for the processes of separation of oil mixtures in distillation columns (for example, vacuum distillation of fuel oil), one of the possible options may be additional identification of the characteristics of the feedstock by curves of true boiling points. To do this, the true ITC curve of the raw material is restored according to the identified situational model M_n^k for calculating the characteristic points of lateral withdrawals and compared with the ITC curves theta correspond to the types of oil introduced into consideration.

In the event theta the situational models for calculating the characteristic points of the ITC of lateral samplings were evaluated, it was proposed to use the following approach.

It has been established theta the pseudo-ITC curves for different types of raw materials, reconstructed from the same M 1 display model with the same measured input parameters $r \in R$ (for example, for a vacuum column of an oil primary processing unit), have a different location relative to each other. Then the aforementioned procedure for restoring the truth of the pseudo-PTC curve can be replaced by reconstructing the pseudo-PTC curve under the same input initial conditions (base values). According to the relative position of the reconstructed and model pseudo-ITC curves, one can judge the qualitative composition of the raw material.

The procedure for bringing the pseudo-ITC curve of the current mode to the basic values of the input parameters for which the model curves are determined

is considered.

Variants of using information about the degree of proximity of the current situation to these identified in the identification of the situational model and the evaluation of the values of the PC product are considered.

The process of learning situational models can be characterized as the formation of a knowledge base about the volume. At the same time, it should be taken into account that: 1) the evaluation of the parameters of the prayer houses is carried out in the mode of normal operation according to the observed data of the parameters of the technological mode of the organization of feedback on the values of the PC. obtained by laboratory; 2) the estimated parameters of the situational models are interconnected withe the procedure for identifying the technological situation; 3) estimation of model parameters can be carried out under the influence of interference on the channels for measuring technological variables, and therefore, the task is to select and adapt interference-resistant algorithms for parametric identification; algorithms for estimating model parameters should make it possible to implement them with minimal effort on the basis of industrial microcontrollers in conditions of limited computer memory resources and use the capabilities of standard libraries; 5) the use of static models for calculating the PC implies a dynamic correction of technological parameters in order to bring them to one time slice, g.e. the operation of dynamic filtering (dynamic alignment of parameters is required.

The purpose of parametric identification of situational models for calculating the PC of products is the maximum approximation of the calculated value of the model n PC values obtained in the laboratory.

Let us formulate in general terms the problem of parametric identification of situational models for calculating PC products. [1]

The task of dividing a set of technological situations into subsets and forming a matrix of coefficients of situational prayer houses is formulated as follows. When developing training procedures for situational models of PC calculation, an assumption is introduced about the invariance of the structure of models for various technological situations. As a result of the study of models of the processes of separation of oil mixtures by rectification methods, it was found theta the structure of PS models, determined

phenomenological or by regression analysis methods, can be taken unchanged in a wide range of variation of attribute variables for typical objects and similar PSs.

The most acceptable option for obtaining models for estimating PC products is to use iterative methods to obtain the structure of PC models and an initial approximation model to improve the rate of convergence of algorithms, and recurrent methods for parametric adaptation of PC models under the influence of interference and the absence of a priori information about interference in observations. The recursive method of stochastic approximation is adopted as the basis for the method for identifying the parameters of the PC calculation models.

When developing training procedures for situational chapels, two possible situations are considered: 1) interference in the channels for measuring parameters is negligible; 2) interference in the channels for measuring parameters is comparable in level with the useful signal. The first assumption makes it possible to form a relatively easy-to-implement algorithm for selecting the coefficient of models for one observation. In this case, the hypothesis of the stationarity of the characteristics is accepted, i.e. the parameters on which training is carried out, measured at a discrete moment n, take the same values under the same external conditions as at the moment n-1 and d . Theism makes it possible to carry out the steps of the stochastic approximation procedure for one observation. Based on this algorithm, models of the initial approximation are formed, which allow accelerating the process of convergence of the stochastic approximation procedure when estimating the coefficients of the models under the influence of noise (by a series of observations).

The peculiarity of applying the method of stochastic approximation to the case under consideration lies in the situational nature of the model of PC products. In this regard, a separate and important task in identifying the parameters of situational models is to assign a series of current observations to the k - the situation.

The following approach is proposed for solving the problem of estimating the parameters of situational models for calculating the PC products from a series of observations.

The intervals of variation of attribute variables are

divided into situational sub- intervals, taking into account the area of model adequacy.

For the k -the situation (k= 1,2,...) are given by the size of the training sample (the number of steps n in the stochastic approximation procedure).

Based on the analysis of logical expressions for the k -the situation, or using pseudo-ITC curves, the problem of assigning current technological parameters to one of the selected situations is solved.

For the k -the situation, the next (first) step of the stochastic approximation procedure evaluates the parameters of the model for calculating the PC products.

The resulting model of the k -the situation is checked for adequacy by calculating the average error in determining the values of the PC either by the training sample or by the generated test sample from the liana of the k-the situation. If the average error of the PC calculation exceeds the specified one, then the training of the model for the k -the situation continues for another n series of observations [4]

The selection of a new technological situation and a situational model for calculating the PC is carried out on the basis of the fulfillment of the condition. At the same time, new situational subranges of variation of attribute variables are determined.

An approximate relationship has been established between the error in measuring the parameters of the technological mode, the number of steps (the size of the training sample) of the stochastic approximation procedure when training the situational model, and the permissible accuracy of estimating the values of the PC of products according to the obtained models. The adequacy of the proposed solutions was tested on the developed simulation model of the vacuum column of the primary distillation unit.

The models represent the following dependencies:
$$t_1^a = \varphi(t_1, P), v_1 = \varphi(t_1^{10}, t_1^{90}), t_1^{ACB} = \psi(t_1^{10})$$

where is the t_1^a ejection temperature a % i -th selection , t -temperate pa i -10 о selection ; P - pressure at the top of the column; v_1, - coefficient of kinematic viscosity i -10 selection: 1 " с " - flash point i -10 selection.

The input parameters of the models are the measured parameters of the technological mode: sampling temperatures and column top pressure. In addition, to identify the technological situation and the model for calculating the PC, information is used on the values of the flow rates of raw materials into the column and the distillation products withdrawn from the column. Models are trained on the basis of laboratory analyzes of the evaluated products.

According to the compiled training sample (8 observations), training was carried out. There situational models were identified for the considered technological situations. On fig. Figure 2 shows the change in the PC obtained from the models and in the laboratory for the modes of the training sample (13 observations).
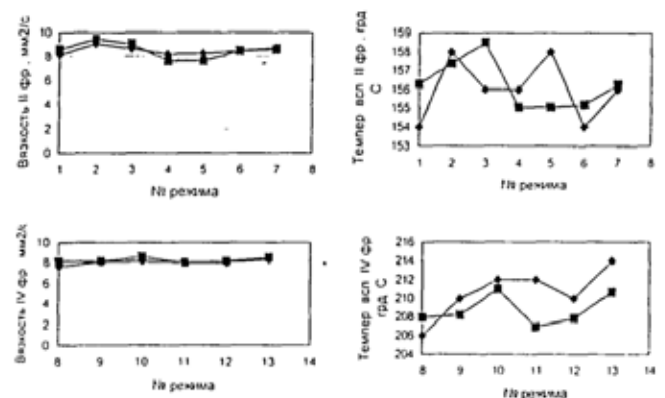
Figure 2 Change in the estimated values of PC for the modes of the training sample (♦ - corresponds to a change in the PC, determined by the laboratory, ■ - coo corresponds to a change in the PC, determined by calculation).

The average relative error estimate of the chemical viscosity of the second fraction for the modes of the training set was -4.5%, the kinematic viscosity of the fourth fraction - 3.2%, the measurement of the flash point of the second (fraction - 1.0%, The obtained situational models for calculating the PC of products make it possible, with an accuracy acceptable for operational control processes (3-5%), to evaluate the values of the PC of products of the vacuum column K-5 of the LVTm-9 installation DO PUNP'Z in the range of variation of the parameters of the technological mode of the training sample. [5]

Conclusion. For the purposes of operational management by PC, it is proposed and justified the use of a model with an unchanged structure. At the same time, the non-linearity and non-stationarity of processes are taken into account by the situational nature of the models for calculating the PC of products, identified, among other things, by non-measurable

process parameters. A classification of identifiable technological situations has been carried out and a method for identifying in the space of measured variables has been developed based on the synthesis and subsequent analysis of logical expressions theta define the situation in variants of two-valued fuzzy logic. It is shown theta the proposed method provides non-discontinuous evaluation of the PC in the transition from one situation to another. The choice of criteria allowing to separate situations and identify unmeasured feature variables based on the developed method of auxiliary operators is substantiated. Algorithms for training situational models for calculating the PC in the mode of normal operation of an object have been developed, providing for both a low and a high level of interference in observations.

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ТЕРМОПОЛЕВАЯ МИГРАЦИЯ И ЭЛЕКТРОДИФФУЗИЯ ЗАРЯЖЕННЫХ ТОЧЕЧНЫХ ДЕФЕКТОВ В ПОЛИКРИСТАЛЛИЧЕСКИХ ПЛЕНКАХ ХАЛЬКОГЕНИДА КАДМИЯ

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Аннотация. Обнаружена корреляция между спектром фотолюминесценции и аномальными фото-вольтаическими свойствами косонапыленных поликристаллических пленок *CdTe, CdTe:ln*. В спектрах чистых образцов наряду краевой дублетной полосой доминирует полоса собственной люминесценции, обусловленной наличием потенциальных барьеров на границах зерен. Легирование примесью приводит к тушению дублетной полосы, а дальнейшая термическая обработка - к резкой активации собственной полосы, полуширина которой связана максимальным значением генерируемого фотона-пряжения $V_{АФН} \approx 10^3 \ В/см$.

Ключевые слова: Тонкая поликристаллическая пленка, теллурид кадмия, примеси, легирование, термическая обработка, аномальные фотовольтаические свойства, спектр фотолюминесценции, потенциальные барьеры, границы зерен.

$$V_{АФН} = (N-1)\frac{\psi_0 - \psi}{e} \ ,$$

Введение. В последнее время в мире быстро развиваются технологии изготовления тонкоплё-ночных солнечных элементов как альтернатива солнечным модулям из кремниевых пластинок. Поликристаллический *CdTe* является наиболее перспективным фотоэлектрическим материалом, используемым сегодня в производстве тонкоплё-ночных солнечных модулей. Коэффициент полезного действия лабораторных образцов солнечных элементов (СЭ) на основе гетероструктуры n-CdS/p-CdTe постоянно увеличивается и в настоящее время составляет 22,1% при солнечном излучении. Она имеет почти 2/3 части теоретического значения коэффициент полезного действия 28–30% на этих структурах. Поэтому повышение эффективности *CdTe* модулей является чрезвычайно актуальной научно-технической задачей. Для увеличения эффективности фотопреобразования следует уменьшить потери, связанные с отражением и поглощением солнечного излучения, несовершенством технологии, а также необходимо проводить более глубокие исследования наиболее важных характеристик солнечных элементов. Гетероструктура n-CdS/p-CdTe широко исследуется также для получения и других оптоэлектронных приборов, перспективность которых в качестве приемников света обусловлена широкой полосой спектральной чувствительности с почти постоянным значением квантового выхода, что весьма существенно при обработке оптических сигналов.

К сегодняшнему дню, несмотря на широкие исследования ведущих научных центров по разработке технологии и изучении механизмов токо-

прохождения тонкопленочных солнечных элементов на основе поликристаллической пленки CdTe, отсутствуют совершенная оптимальная технология и исчерпывающие физические интерпретации. Усовершенствование технологии получения плёночных CdTe-солнечных элементов и более глубокое изучение их физических характеристик является актуальной и востребованной задачей солнечной энергетики. Поэтому проблемой исследования диссертации выбрана разработка термовакуумной технологии получения пленочной гетероструктуры n-CdS/p-CdTe с фоторезистивными и аномальными фотовольтаическими (АФВ) свойствами и изучение фотоэлектрических, оптических свойств слоя p-CdTe с дополнительной подсветкой n-CdS. При этом основное внимание обращено исследованиям роли межзеренных границ, примесно-дефектного состава приграничных и внутренних областей кристаллических зерен в формировании электрических, фотоэлектрических свойств и спектров люминесценции мелкозернистой пленки CdTe.

Литературный обзор и методология. Изучение механизмов миграция и электродиффузия заряженных точечных дефектов внутри образца является актуальным направлением исследований, имеющим фундаментальное значение и практический интерес, связанный с прочностными свойствами материалов. Открытие таких явлений, как эффект «малых доз» [1] и эффект дальнодействия [2], стимулирует особое внимание к этой проблеме. А также, в данной работе рассматривается вопрос о взаимосвязи формы спектра низкотемпературной фотолюминесценции (НТФЛ) с аномальными фотовольтаическими (АФВ) свойствами косонапыленных пленок $CdTe$, $CdTe:In$

в зависимости от структурных несовершенств. Так, с помощью изучения динамики изменения спектров фотолюминесценции авторы работ [1-3] предложили метод глубокой очистки образцов $CdTe$ и получили поликристаллический $CdTe$ стехиометрического состава, в спектре фотолюминесценции которого полностью отсутствует примесное излучение и остается только экситонная часть. Анализом формы краевого излучения при лазерном возбуждении исследованы электронные спектры твердых растворов $CdTe:In$ [4].

Прежде чем перейти к рассмотрению спектров

НТФЛ в чистых и легированных примесями In тонких поликристаллических слоях $CdTe$ в начале попытаемся выяснить причины столь существенного влияния процессов легирования примесью ln и последующей ТО на фотовольтаические свойства пленок, анализируя механизмы образования, миграции и самокомпенсации фоточувствительных заряженных точечных дефектов.

Результаты. Исходя из реального процесса роста тонкого полупроводникового слоя на аморфной прозрачной диэлектрической подложке при термовакуумном напылении в указанных выше технологических условиях, можно представить, что косонапыленная поликристаллическая пленка формируется в виде своеобразной трехслойной структуры: наличие верхнего и нижнего асимметричных дендритных слоев, между которыми образуется канал протекания (электропроводящий-шунтирующий слой) (рис.1).

Рис.1. Схематическая модель косонапыленной поликристаллической пленки, выращенной на стеклянной подложке: ВД – верхние дендриты, НД – нижние дендриты, КЗ – кристаллическое зерно, КП - канал протекания.

Эти три слоя играют различную роль в формировании фотовольтаических свойств пленок [3,4]. Так, например, уменьшение температуры подложки развивает нижние дендриты, возможно, и стимулирует АФН, а увеличение толщины пленок приводит к резкому росту электропроводности канала протекания, следовательно, и - к падению $V_{АФН}$. Для краткости здесь мы ограничимся рассмотрением роли нижнего дендритного слоя (НДС), которого в направлении прохождения тока можно схематически представить как линейную периодическую цепочку последовательно включенных участков полупроводник - диэлектрик – полупроводник (ПДП) с асимметричными поверхностными электрическими свойствами слева

и справа от диэлектрического слоя (ДС).
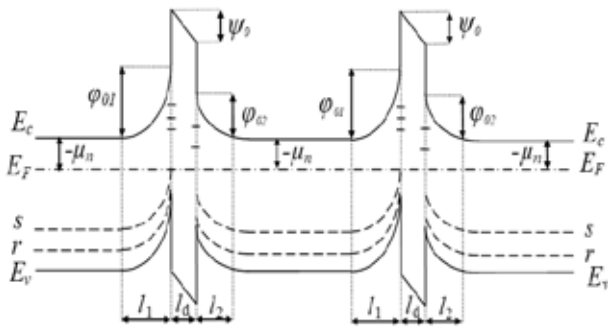
Рис.2. Схематическая энергетическая зонная диаграмма цепочки кристаллических зерен с асимметричными потенциальными барьерами на границе кристаллитов с порами для нелегированной фотовольтаической пленки $CdTe$ в состоянии термодинамического равновесия.

Образование равновесных асимметричных приповерхностных потенциальных барьеров с обеих сторон ДС, а значить и контактной разности потенциалов $\psi_0 = (\phi_{01} - \phi_{02})/e$ в каждой элементарной ячейке (рис.2) обуславливает генерации высоковольтной фото-ЭДС в линейной цепочке ПДП – структуры при освещении:

$$V_{A\Phi H} = (N-1)\frac{\psi_0 - \psi}{e}, \ (1)$$

где N- число периодически расположенных кристаллических зерен (КЗ) вдоль пленки, $\psi_0 = \phi_{01} - \phi_{02}$ и $\psi = \phi_1 - \phi_2$; ϕ_{0i} и ϕ_i - высоты поверхностных потенциальных барьеров до и после воздействия света слева (i=1) и справа (i=2) от ДС. Согласно данной модели можно заключить, что путем развития степени асимметричности барьеров ϕ_{01} и ϕ_{02} с помощью определенных технологических приемов можно увеличить максимальное значение $V_{A\Phi H}$ и I_{K3}. Легирование по вышеуказанной методике примесью In и последующая ТО косонапыленных пленок $CdTe$ является одним из таких технологических решений. Возникает естественный вопрос о механизме, ответственном за увеличение на два порядка значения $I_{\kappa3}$. и на порядок - $V_{A\Phi H}$ в процессе ТО пленок $CdTe$:In в пределах достаточно низких температур 250-300 ^{0}С по сравнению с нелегированными пленками. Ответ на данный вопрос можно получить, рассматривая процессы образования и миграции точечных заряженных дефектов решетки в легированном In косонапыленном слое $CdTe$. Здесь мы имеем дело с известными явлениями самокомпенсации и электродиффузии в

тонких поликристаллических пленках [4-6]. Действительно, поскольку примесные атомы In внедрялись в поликристаллический слой $CdTe$ непосредственно в процессе роста пленки, то можно считать, что объем КЗ до ТО достаточно однородно легирован.

Легированные образцы $CdTe$:In до ТО содержали сравнительно малую концентрацию V_{Cd}^- и обнаруживали ярко выраженную низкоомную проводимость n-типа. Достаточно высокий уровень легирования (растворимость In в кристаллах $CdTe$ достигает до 10^{-5} моль % [7]) в некоторой степени сглаживает асимметричность потенциальных барьеров на границах ДС (рис.3) и увеличивает электропроводность шунтирующего слоя, следовательно, снижает способности пленки генерировать АФН.
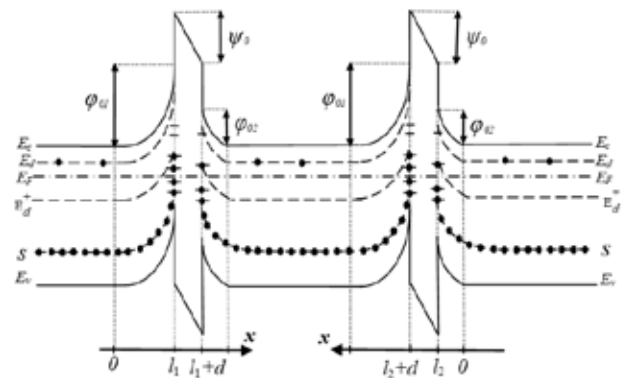
Рис.3. Схематическая модель энергетической зонной диаграммы легированной фотовольтаической пленки CdTe : In после термической обработки.

Относительно большое значение фототока короткого замыкания I_{K3} =2·10-8А в основном обусловлено, по - видимому, высокой поверхностно–барьерной фотопроводимостью, кратность которой достигает $R_{TEM}/R_{CB} \approx 10^2$ отн ед. Вообще говоря, во время ТО пленок $CdTe$:In следует естественно ожидать следующие процессы в объеме КЗ [4,5]:во-первых, термическую активацию-дислоцирование атомов замещения In_{K3}, что приводит к образованию междоузельных ионов In_i^{+i} и вакансий кадмия V_{Cd}^{-j}: $In_{Cd} \to In_i^{+i} + V_{Cd}^{-j}$; во-вторых, самокомпенсацию донорных (In^{+i}) и акцепторных (V_{Cd}^{-j}) центров (заведомо образуются донорно-акцепторные пары (ДАП) или примесные комплексы вида ($In^{+i} V_{Cd}^{-j}$)), которая сопровождается переходом КЗ и его поверхности из

низкоомного состояния в сильно высокоомное. Последнее, в свою очередь, обуславливает расширение ООЗ и рост высоты поверхностных потенциальных барьеров на границах КЗ (рис. 3), что и отражается, в конечном итоге, в росте темнового сопротивления пленки при ТО ; в третьих, миграцию точечных заряженных дефектов из объема КЗ на его поверхность и наоборот. Однако процессы образования подобных вакансий, примесных комплексов и их миграция при ТО косонапыленных поликристаллических слоев $CdTe$ существенно отличаются от аналогичных процессов в массивных кристаллах и в обычных поликристаллических пленках [6]. Естественно, что во время ТО внутрикристаллическое электрическое поле (т.е. приповерхностное поле ООЗ) в исследуемых пленках $CdTe : In$ вызывает дрейф дислоцированных положительно заряженных атомов индия In_i^{+i} по вакансиям кадмия, направленный из объема в сторону поверхности зерна, и обратно направленный дрейф отрицательно заряженных вакансий кадмия от поверхности зерна в сторону его объема. В результате таких встречных термополевых миграцией (ТПМ) ионов In^{+i} и вакансий V_{Cd}^{-j} формируется их неоднородное пространственное (термодинамически равновесное, например, больцмановское) распределение:

$$N_{In^{+i}}(x) = N_{In^{+i}}(0) \cdot e^{\frac{e\varphi(x)}{kT}} , \quad N_{V_{Cd}^{-j}}(x) = N_{V_{Cd}^{-j}}(0) \cdot e^{-\frac{e\varphi(x)}{kT}} , \quad (2)$$

что вызывает обратный поток биполярной диффузии этих точечных дефектов, уравновешивающий, в конечном счете, их поток за счет ТПМ. Здесь $N_{In^{+i}}(0)$ и $N_{V_{Cd}^{-j}}(0)$ - концентрация ионов In^{+i} и вакансий V_{Cd}^{-j} на границе между квазинейтральным объемом и ООЗ (рис.3).Особо следует отметить, что ТПМ In^{+i} и V_{Cd}^{-j} по обе стороны диэлектрического слоя происходит в ассиметричных электрических полях, в результате чего количество ионов In^{+i}, выходящих на границу КЗ, слева от ДС будет значительно больше, чем справа. В барьерных областях l_1 и l_2 (рис.3) одновременно будут происходить асимметричные ТПМ и электродиффузия ионов под действием "встроенных" внутри-кристаллических электростатических полей ООЗ. При истощенных изгибах краев энергетических зон в приграничной области кристалли-

ческого зерна n-типа барьерное электрическое поле $\overline{E_{BC}}$ анизотропно влияет на ТПМ и электродиффузии In^{+i} и V_{Cd}^{-j}, а именно $\overline{E_{BC}}$ замедляет электродиффузию V_{Cd}^{-j} и наоборот, ускоряет ТПМ In^{+i} к границам зерен. Выходящие на границу зерен ионы In^+ частично компенсируют поверхностные акцепторные состояния, что влечет за собой увеличение сродства поверхности к электронам и рост как высоты, так и асимметричности барьеров на противоположных границах КЗ. При этом естественно увеличивается насыщение поверхностных оборванных связей за счет ТПМ ионов In^{+i}, V_{Cd}^{-j} и их заряженных комплексов, которое вызывает дополнительный рост темнового сопротивления отожженной пленки $CdTe : In$ из-за уменьшения шумовых токов, т.е. поверхностной электропроводности КЗ. Такие сложные процессы самокомпенсации, ТПМ и электродиффузии, в конечном счете, поддерживают процессы реиспарения атомов Cd и In от естественной поверхности пленки. Межзеренные границы являются благоприятственными для зернограничной диффузии [7] разрыхленными прослойками, где коэффициент диффузии атомов почти на порядок больше, чем внутри кристаллита. Математическое моделирование диффузии двухзаряженных примесей в полупроводнике с учетом внутреннего электрического поля проводилось во многих работах (см. например, [6,7]). В нашем случае процессы ТПМ и электродиффузии заряженных дефектов в ОПЗ (рис. 3, $0 \le x \le l1$ и $0 \le x \le l2$) при линейном континуальном пределе вдоль оси х можно описать системой уравнений:

$$\frac{\partial N_\alpha^i(x,t)}{\partial t} = D_\alpha \frac{\partial^2 N_\alpha^i(x,t)}{\partial x^2} + \mu_\alpha \frac{\partial}{\partial x}\left(N_\alpha^i(x,t)\frac{\partial \phi_i(x,t)}{\partial x}\right) + \gamma_\alpha(N_{In_{Cd}} - \sum_\alpha N_\alpha^i(x,t)) ,$$
(3)

$$\frac{\partial^2 \phi_i(x,t)}{\partial x^2} = \frac{e}{\varepsilon\varepsilon_0}\left(n_i(x,t) - p_i(x,t) + \sum_\alpha z_\alpha N_\alpha^i(x,t)\right),$$
(4)

$$\int_0^{l_i}\left(n_i(x,t) - p_i(x,t) + \sum_\alpha z_\alpha N_\alpha^i(x,t)\right)dx = \sum_\beta z_\beta N_{s\beta}^i(t) .$$
(5)

Здесь $i = 1$ слева и $i = 2$ справа от ДС; N_α^i, D_α,

μ_α, z_α и γ_α - концентрация, коэффициент диффузии, подвижность, эффективный заряд и коэффициент скорости термической генерации α- заряженного центра (например, α = 1 для In_i^+ и α = 2 для V_{Cd}^{-2}); n и p – концентрация свободных электронов и дырок, $N_{s\beta}^i$ – концентрация поверхностного β- уровня с зарядовым состоянием zβ, e- абсолютное значение заряда электрона, ε_0 -электрическая постоянная, ε-диэлектрическая проницаемость КЗ, t-время ТО. Коэффициенты Dα и μα удовлетворяют соотношению Эйнштейна Dα = zα μαe/kT, причем для доноров zα > 0, μα> 0, а в случае акцепторов zα <0, μ_α <0. Уравнения (3), (4) и (5) посуществу являются уравнениями непрерывности, Пуассона и электронейтральности [8-9].

Как правило, уравнения (3) и (4) можно численно решить методом разностных схем [8] и построить зависимость $\phi_i(x,t)$. Это давало бы возможность следить за кинетикой изменения асимметрии барьеров ϕ_1 и ϕ_2 в процессе ТО и, в конечном счете, под действием освещения. Однако, такая интересная трудоемкая задача выходит за рамки настоящей диссертации и здесь для краткости мы ограничимся грубой оценкой коэффициента биполярной диффузии заряженных центров In_i^{+i} и V_{Cd}^{-j} . Если допустить, что время оптимального очувствления $V_{АФН}$ обратно пропорционально коэффициенту миграции (электродиффузии) индия In_i^+ (или вакансий кадмия V_{Cd}^{-j}) $\tau \sim D^{-1} \sim \exp\left(\frac{\Delta E_D}{kT}\right)$, то для

D можно получить при T=800 K значение $D \sim 10^{-12}$ см^2/с[9-10], что неплохо согласуется с литературными данными [6-8]. Таким образом, процесс ТО поликристаллических пленок $CdTe:In$ можно описать на языке ТПМ и электродиффузии.

Заключение. В заключение этого параграфа лишний раз заметим, что легирование индием косонапыленных пленок $CdTe$ качественно изменяет его фотовольтаические свойства: увеличивается максимальное значение $V_{АФН}$ на порядок, а $I_{кз}$ - более чем на два порядка; обнаруживается резкая температурная зависимость $I_{кз}$ и его спектра

[8-10].

Разработана технология получения аномально фотовольтаической пленки методом вакуумного испарения $CdTe$ и легирующей примеси In в количестве 3-7 масс.% из различных тиглей при давлении остаточных газов 10^{-3} - 10^{-5} мм. pt. cт. на стеклянную подложку с температурой $250-300$ ^0C, причем напыление In задерживают на 2-3 мин. и прекращают на 3-5 мин. раньше, чем напыление $CdTe$, а термообработку проводят в атмосфере воздуха в присутствии паров CdCl2 при температуре 250 ^0C в течение 2-4 мин.

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OPERATIONAL CONTROL OF THE VACUUM COLUMN OF THE UNIT OF OIL PRIMARY DISTILLATION

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Annotation: The cybernetic foundations of the problem of modeling and algorithmization of the control of the vacuum unit of the primary oil refining unit of the CDU-AVT type, which makes it possible to increase the economic efficiency of the production of the resulting commercial oil products, have been studied.

Keywords: vacuum unit, mathematical formulation of the problem, optimal control, technological process, oil, primary oil refining

Introduction. In the commodity structure of international trade, oil, gas and products of their primary processing have been occupied and stably kept for many years, which are significantly ahead of all other goods and items of export-import operations, which determines their key role in the regional commercial energy balance.

The main systemic problems of oil refining as a key element of the oil industry include the following: low oil recovery factor, low quality and unstable composition of oil products, insufficient automation and quality control of oil refining processes, insufficient efficiency of existing production equipment; low depth of processing, discrepancy between the quality of the final product and export requirements, and some others.

The ever-increasing competition in the global economy and the transition to new standards of energy and resource saving, quality and environmental safety create the need for continuous tightening of requirements for primary oil refining processes, which causes an obvious need to develop new systematic approaches to increase production efficiency in the oil industry, optimizing the management of the main processes and, as a result, improving the quality of the final products of oil refining.

The pronounced systemic nature of this problem determines the need to solve it on the basis of system research using modern methods and tools of system analysis, modeling theory, control and optimization.

One of the main problems of primary oil refining is the insufficient level of efficiency of the existing equipment and the quality of control, the solution of which can be achieved by a systematic analysis of typical industry-specific oil refining processes as objects of control and optimization according to frequency criteria of the quality of multiloop cascade control systems.

Literature review and methodolgy. The process of primary oil refining is the most high-tonnage, energy-intensive and resource-intensive. This circumstance determined the choice of the process of primary oil refining at atmospheric-vacuum distillation units as a complex object of system analysis, control and optimization.

To date, there is no unified strategy for the system analysis of typical industry multi-stage processes of primary oil refining, which, based on integrated system quantitative assessments, can identify inefficiently controlled technological parameters and develop recommendations for optimizing the corresponding multi-loop cascade control systems. [1]

A multi-stage process of primary oil refining as a complex technical object of control and optimization, which includes the following stages:

1. Analysis of the system structure of the primary oil refinery, including the definition and characterization of input and output flows; drawing

up structural and enlarged process diagrams, as well as operator diagrams of blocks and nodes, which reflect topological connections and allow classifying parameters and interconnected flows of blocks and nodes.

2. Analysis of the process control subsystem of an oil refinery, including the compilation of a list and passports of existing local control systems, which indicate the characteristics of parameters and flows, as well as absolute and integral indicators of the quality of control processes in steady-state and transient modes of operation.

3. Analysis of the information-measuring subsystem, including the study of the composition of the complex of technical means and the quality of measuring the parameters of flows and equipment; definition of requirements for their measurements; analysis of the characteristics of existing measuring instruments; assessment of the quality of measuring the parameters of flows and equipment.

4. Analysis of subsystems of interlocks and protections, including the study and characterization of the composition and performance of automatic systems of interlocks and emergency protection, as well as an assessment of the degree of their compliance with the requirements for the performance of the control system.

5. Analysis of the energy efficiency of the oil refining process, including the characteristics of the received and received oil products for the reporting period, the calculation of the planned and actual specific consumption of thermal energy for processing, the determination of the degree of energy efficiency of the process.

6. Analysis of the level of automation of the oil refining process, including the determination of quantitative and qualitative indicators of the degree of automation of the following functions: process control; control of quality indicators of streams; control and registration of parameters of streams and equipment; analysis of regime situations; transfer of information to the upper level of management; start and stop equipment. [2]

7. Analysis of the reliability of the control system, including the compilation of a design logic diagram of reliability and the calculation of the failure rate of all components of the system.

8. Comparative analysis of the relative effectiveness of local ATS based on the DEA method (Data Envelopment Analysis) and includes an assessment of the relative integral indicators of the quality of regulation of local loops in static and dynamic modes, which allows you to set the parameters that the control meets the requirements and identify how far the indicators of inefficiently controlled parameters are far from their potentially possible effective values.

9. Formation of a conclusion on the quality of management, in case of compliance with the requirements, recommendations are developed on the practical use of the results of the system analysis, and the task is considered solved, otherwise the transition to the subsequent stages of the system analysis is carried out.

10. Analysis of the dynamics of circuits with inefficiently controlled parameters, including the selection and justification of mathematical models focused on the use in parametric optimization problems to describe the objects of regulation of local automatic control systems in the form of transfer functions for the considered channels of action of master and disturbing influences.

11. Parametric optimization by frequency quality criteria of typical controllers of local automatic control systems with inefficiently controlled parameters of a multiloop control system based on the alternance optimization method.

12. Evaluation of the absolute quality indicators of control processes in optimized local loops in static and dynamic modes of operation, after which the transition to stage 8 is carried out.

The main task of the considered multi-loop control system is to control the temperature of fuel oil at the furnace outlet, and the main disturbances, for which the ACS is designed to compensate, are the fuel oil temperature at the furnace inlet, fuel oil consumption in the vacuum column and superheated steam consumption at the furnace coils inlet.

For the mathematical description of the processes of movement of liquid and vapor through the pipeline, which have a significantly lower inertia compared to other processes occurring in the vacuum unit of the AVT installation, first-order aperiodic links were used.

The resulting mathematical description is oriented to further use in optimization procedures when solving the problem of parametric optimization of a multi-loop automatic control system by the process of heating raw materials. [2]

Ensuring the maximum degree of invariance of local control loops with respect to each other and to external disturbances can be considered as the main optimality criterion in the problems of parametric synthesis and optimization of cascade automatic control systems, taking into account additional requirements for the quality of transient processes formulated in the form of given restrictions on the maxima of the amplitude-frequency characteristics of local closed circuits of the synthesized system through the channels of the setting influences.

Results. In the most general case, a multiloop cascade control system, including n loops, can be represented as shown in Figure 2, where $z_i(s)$ is the controlled variable i of the -th loop; $W_{ui}(s)$ and $W_{fi}(s)$ are the correct rational transfer functions of the control object i of the th circuit through the channels of the control and disturbing influences $u_i(s)$ and $f_i(s)$, respectively. In this case, the transfer function $W_{fi}(s)$ can contain any necessary information that satisfies the hypothesis of the low-frequency nature of the disturbances. [3]

Transfer Functions of Regulators $W_{pi}(s,\Delta_i), i=\overline{1,n}$ are considered to be functions of the desired vectors $\Delta_i=(\Delta_{ij}), j=\overline{1,k_i}$ of unknown parameters of their settings, given in the standard fractional-rational form.
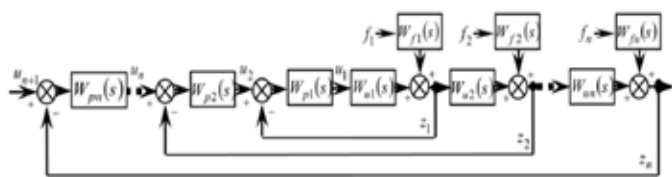
Figure 1 - Structural diagram of the cascade control system

In a number of practical cases, as an optimization criterion $I_i(\Delta_i)$ i - circuit, it is advisable to choose the maximum amplitude-frequency characteristic $I_i(\Delta_i) = \max_{\omega \in [0,\infty)}\left|W_{zfi}(i\omega,\Delta_i)\right|$ of this circuit through the channel of the perturbing action, which has a transfer function $W_{zfi}(s,\Delta_i)$. As a result, the problem is reduced to finding n parameter vectors

$\Delta_i=(\Delta_{ij}), j=\overline{1,k_i}, i=\overline{1,n}$ settings of regulators that minimize the maximum frequency response of all circuits of the nominal system through the channels of disturbance action:

$$I_i(\Delta_i) = \max_{\omega \in [0,\infty)}\left|W_{zfi}(i\omega,\Delta_i)\right| \to \min_{\Delta_i \in G_n \subset E^n}, i=\overline{1,n},$$

(1)

where G_n is the set of parameters Δ_i that ensures the stability i of the contour; $W_{zfi}(i\omega,\Delta_i)$- amplitude-phase characteristic i of the -th circuit along the perturbation channel.

At the same time, the requirements for the quality indicators i of the th circuit can often be formulated as a restriction on the maximum frequency response $\left|W_{zui}(i\omega,\Delta_i)\right|$ of this circuit through the channel of the driving influence, where $W_{zui}(i\omega,\Delta_i)$ is the amplitude-phase characteristic i of the -th circuit along the channel of the driving influence. As such a limitation, it is advisable to consider the limitation on the value of the oscillation index M_i, which is the maximum value of the amplitude-frequency characteristic $\left|W_{zui}(i\omega,\Delta_i)\right|$ on the frequency axis in relative units:

$$F_i(\Delta_i) = \max_{\omega \in [0,\infty)}\left|W_{zui}(i\omega,\Delta_i)\right| \le M_i, i=\overline{1,n}.$$

(2)

Thus, we come to the parametrized problem (1)-(2) of optimizing n control loops of a multidimensional cascade system, while the problem of parametric synthesis i of the loop is reduced to the standard form of the following semi-infinite optimization problem:

$$I_i(\Delta_i) = \max_{\omega \in [0,\infty)}\left|W_{zfi}(i\omega,\Delta_i)\right| \to \min_{\Delta_i \in G_n \subset E^n},$$

(3)

$$F_i(\Delta_i) = \max_{\omega \in [0,\infty)}\left|W_{zui}(i\omega,\Delta_i)\right| \le M_i,$$ (4)

in which it is required to find the vector of optimal parameters $\Delta_i=(\Delta_{ij}), j=\overline{1,k_i}$ typical regulator $W_{pi}(s,\Delta_i)$, which provides the minimum response i of the i- circuit to an external disturbing action according to criterion (3) under the conditions of limitation (4) on the index of the oscillatory processes of transients i of the i-circuit along the setting channel. [4]

With the chosen structure of the controller, $W_{pi}(s, \Delta_i)$, the problem (3)-(4) of parametric synthesis of the optimal controller is a mathematical programming problem with an infinite number of restrictions of type (4), which is proposed to be solved in the paper on the basis of the alternance method of parametric optimization.

According to this method, the solution of problem (3)-(4), which is a certain vector of parameters Δ_i^{opt}, satisfies special alternance properties, according to which on the frequency axis $\omega \in [0; +\infty)$ there are at least $R_{fi} \geq 1$ different points $\omega_{fiq}, q = \overline{1, R_{fi}}$ and $R_{ui} \geq 1$ various points $\omega_{uis}, s = \overline{1, R_{ui}}$ at which the amplitude-frequency characteristics $\left| W_{zfi}(i\omega, \Delta_i^{\mathrm{opt}}) \right|$ And $\left| W_{zui}(i\omega, \Delta_i^{opt}) \right|$ reach their maximum values equal to $I_i(\Delta_i^{\mathrm{opt}})$ and $F_i(\Delta_i^{opt}) = M_i$, respectively, under the condition:

$$R_{fi} + R_{ui} = k_i + 1, \tag{5}$$

where k_i is the number of desired controller settings $W_{pi}(s, \Delta_i)$.

An exception is the situation when there is a minimum number of such points, i.e. $R_{fi} = 1$ and (or) $R_{ui} = 1$, then the inequality is possible $R_{fi} + R_{ui} < k_i + 1$ if $k_i \geq 2$.

The noted properties make it possible to compose in the case (5) a closed system $k_i + 1$ equations for frequency response $\left| W_{zfi}(i\omega, \Delta_i^{opt}) \right|$ And $\left| W_{zui}(i\omega, \Delta_i^{\mathrm{opt}}) \right|$ about all $k_i + 1$ desired parameters, which are k_i component $\Delta_i^{\mathrm{opt}} = (\Delta_{ij}^{opt}), j = \overline{1, k_i}$ vector Δ_i^{opt} and minimax $I_i(\Delta_i^{opt})$.

If there is additional information about the form of the corresponding AFC, this system of equations can be supplemented with the condition for the existence of an extremum of the indicated frequency characteristics at these points. Then we get the system $2(k_i + 1)$ equations, the solution of which are k_i the parameters of the controller settings

$\Delta_i^{\mathrm{opt}} = (\Delta_{ij}^{\mathrm{opt}}), j = \overline{1, k_i}$; magnitude $I_i(\Delta_i^{opt})$, frequencies $\omega_{fiq}^{\mathrm{opt}}, q = \overline{1, R_{fi}}$ and $\omega_{uis}^{opt}, s = \overline{1, R_{ui}}$:

$$
\begin{cases}
\left| W_{zfi}(i\omega_{fiq}^{\mathrm{opt}}, \Delta_i^{\mathrm{opt}}) \right| - I_i(\Delta_i^{\mathrm{opt}}) = 0; \dfrac{\partial \left| W_{zfi}(i\omega_{fiq}^{\mathrm{opt}}, \Delta_i^{\mathrm{opt}}) \right|}{\partial \omega} = 0; q = \overline{1, R_{fi}}; \\
\left| W_{zui}(i\omega_{uis}^{\mathrm{opt}}, \Delta_i^{\mathrm{opt}}) \right| - M_i = 0; \dfrac{\partial \left| W_{zui}(i\omega_{uis}^{\mathrm{opt}}, \Delta_i^{\mathrm{opt}}) \right|}{\partial \omega} = 0; s = \overline{1, R_{ui}}; R_{fi} + R_{ui} = k_i + 1
\end{cases}
$$

(6)

For an unambiguous representation of the system of equations (6), a preliminary unambiguous choice of a combination of quantities is required, which requires additional analysis R_{fi} and R_{ui}, implemented within the framework of the variant under consideration, after which the problem is reduced to solving this system. [5]

For a typical case, when $R_{fi} + R_{ui} = k_i < k_i + 1$, system (6) is supplemented by an equation written as a condition of equality to zero of the determinant, composed of the derivatives of the frequency response over the reference and disturbance channels for the desired controller parameters:

$$\det \left[\frac{\partial \left| W_{zui}(i\omega_{uis}^{\mathrm{opt}}, \Delta_i^{\mathrm{opt}}) \right|}{\partial \Delta_{ij}}; \frac{\partial W_{zfi}(i\omega_{fiq}^{\mathrm{opt}}, \Delta_{fis}^{\mathrm{opt}})}{\partial \Delta_{ij}} \right] = 0,$$

$$s = \overline{1, R_{ui}}; q = \overline{1, R_{fi}}; R_{ui} + R_{fi} = k_i; j = \overline{1, k_i}.$$

(7)

To solve the problem of parametric synthesis and optimization of a multi-loop cascade ACS based on the alternance method, the following algorithm is proposed in the work:

1. At the first stage, the requirements for the quality of regulation in the frequency domain are formulated in the form of setting restrictions on the oscillation indicators $M_i, i = \overline{1, n}$ for all control loops.

2. At the second stage, the optimal settings are determined $\Delta_1^{\mathrm{opt}} = (\Delta_{1j}^{\mathrm{opt}}), j = \overline{1, k_1}$ typical control loop controller $i = 1$ according to the scheme of the alternance method described above , based on the requirements for ensuring a given degree of oscillation M_1 of the first circuit through the channel of the master influence and minimization of the circuit's response to an external unregulated disturbing influence f_1.

3. At each subsequent stage, the problem of parametric synthesis of a typical controller of the i-control loop is solved $\left(i = \overline{2, n}\right)$, i.e. optimal settings are determined $\Delta_i^{\mathrm{opt}} = \left(\Delta_{ij}^{\mathrm{opt}}\right), j = \overline{1, k_i}, i = \overline{2, n}$ regulator according to the scheme of the alternance method, based on the requirements for providing a given degree of oscillation M_i of the circuit under consideration through the channel of the driving influence and minimizing the response of the circuit to an external unregulated perturbing influence f_i, with the optimal settings of the regulators determined at the previous stages $\Delta_l^{\mathrm{opt}} = \left(\Delta_{lj}^{\mathrm{opt}}\right), j = \overline{1, k_l}, l = \overline{1, i-1}$ contours from the 1st to (i -1).

4. At the final stage, the quality of the obtained transient processes of the system and its stability are assessed.

The developed algorithm for parametric synthesis of typical controllers was first tested in relation to a typical ACS by the process of heating the raw materials of the vacuum unit of the AVT installation, which has the worst integral estimates of the efficiency of local control loops of technological parameters. [6]

The thesis considers a typical block diagram of a multi-circuit automatic control system for the process of heating raw materials (Figure 2), consisting of a cascade system with two control loops (regulators $W_{p1}(s, \Delta_1)$ and $W_{p2}(s, \Delta_2)$) for the temperature of the fuel oil at the outlet of the furnace (z_2) and changing the flow of fuel oil supplied to the furnace (z_1), and a single-circuit control system (regulator $W_{p0}(s, \Delta_0)$) of the steam flow to the furnace (z_0).
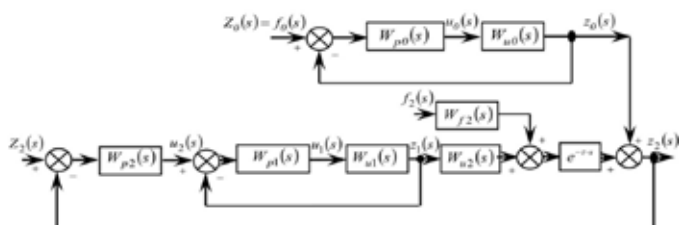
Figure 2 - A typical block diagram of the ACS by the process of heating raw materials

The control object of the internal loop is a section of the pipeline with a transfer function $W_{u1}(s)$, through which fuel is supplied to the furnace.

The transfer function of the control object of the external loop of the cascade system is a linear combination of the transfer function of the closed internal loop and the transfer function $W_{u2}(s)$, which describes the change in the temperature of the raw material volume (z_2) heated in the furnace, and can be represented by a second-order aperiodic link. [7]

The cascade system is affected by external disturbances, the main of which include a change in flow (f_2) superheated steam into the furnace and change in flow (f_0) processed raw materials (fuel oil). At the same time, the consumption (z_0) superheated steam supplied to the furnace is regulated by a local single-circuit ACS (regulator $W_{p0}(s, \Delta_0)$), in which the control action (u_0) is the change in steam flow in the furnace coils.

The control object, described by the transfer function $W_{u0}(s)$, is a section of the steam pipeline through which steam is supplied to the furnace.

In the ACS scheme considered by the structure, the link of the transport delay is assigned to the outputs of the object and the noise filter f_2.

Transfer functions of control objects $W_{u0}(s)$, $W_{u1}(s)$, $W_{u2}(s)$ with constant coefficients are presented in Table 1. Transfer functions of typical regulators $W_{pi}(s, \Delta_i), i = \overline{0, 2}$ are considered to be given up to parameter vectors $\Delta_i = (\Delta_{ij}), j = \overline{1, k_i}$ and representable in the standard fractional rational form.

The proportional-integral-differential (PID) law is chosen as the control laws, which is the most universal of the typical control laws and has the greatest control capabilities. Thus, the problem of parametric synthesis and optimization is reduced to the problem of finding the optimal tuning parameters for typical PID controllers in a multi-circuit automatic control system by the process of heating the raw materials of the vacuum unit of the AVT unit.

To solve this problem, we developed an algorithm for solving the problem of parametric optimization of typical controllers in a multiloop control system, which includes the following steps.

1. At the first stage of the solution, using the alternance method, the tuning parameters are

determined $\Delta_1^{opt} = (\Delta_{1j}^{opt})$, $j = \overline{1,3}$ internal loop controller $i = 1$ cascade system, for which the channel "disturbing influence - controlled value" is not set.

2. The second stage of solving the problem is the optimization of the outer contour $i = 2$ cascade system, i.e. search for a vector of settings parameters Δ_2^{opt} controller $W_{p2}(s, \Delta_2)$ from the condition of minimizing the response of the ACS to the disturbing action f_2. The solution is carried out according to the scheme of the alternance method described above with fixed (obtained at stage 1) optimal values of the tuning parameters Δ_1^{opt} regulator $W_{p1}(s, \Delta_1^{opt})$. In this case, the optimization criterion $I2(\Delta_2)$ is given in the form of functional (3) minimizing the maximum of the amplitude-frequency characteristic $|W2_{zf2}(i\omega, \Delta_1, \Delta_2)|$ contour along the channel of the action of the perturbation f_2, and the restriction $F2(\Delta_2)$ of the form (4) is superimposed on the maximum of the amplitude-frequency characteristic $|W2_{zu}(i\omega, \Delta_1, \Delta_2)|$ contour on the reference channel. [8]

3. At the third stage of solving the problem of parametric optimization of ACS by heating raw materials, the vector is determined Δ_0^{opt} controller settings $W_{p0}(s, \Delta_0)$ local ATS of steam flow to the furnace. A feature of the application here of the procedure of the alternance method described above is the choice as an optimality criterion $I0(\Delta_0)$ maximum frequency response of the cascade automatic control system for the perturbation channel $|W2_{zf0}(i\omega, \Delta_0, \Delta_1^{opt}, \Delta_2^{opt})|$, for which the synthesized control loop acts as an external controlled influence with pre-fixed optimal values of the tuning parameters of the local controllers of the cascade system Δ_1^{opt} and Δ_2^{opt}, found at steps 1 and 2. Constraint $F0(\Delta_0)$ limits the maximum frequency response $|W0_{zu}(i\omega_{us}^{opt}, \Delta_0^{opt})|$ contour to be optimized $i = 0$ through the channel of the master influence.

4. At the final stage, the quality of control processes in the time domain is evaluated and the effectiveness of the ACS after parametric optimization is analyzed based on system integral estimates obtained by the DEA method.

The described algorithm was tested in solving the problem of parametric optimization of a multi-loop automatic control system by heating raw materials for the cases of the presence and absence of transport delay links in the structure of control objects. [9]

The results of solving the problem of parametric optimization of a multi-circuit automatic control system by the process of heating raw materials in the presence of a delay link in the structure of control objects are presented in tables 2-4 for various values of the oscillation indices of local circuits M0, M1 and M2.

Table 1. Transfer functions of the control objects of the automatic control system for the raw material heating

ACS contour	Transfer function, W(s)	Transp. late .
1	$W_{u1}(s) = \dfrac{1}{16 \cdot s + 1};$	0
2	$W_{u2}(s) = \dfrac{48}{742 \cdot s^2 + 239 \cdot s + 1}; W_{f2}(s) = \dfrac{3,6 \cdot (4,67 \cdot s + 1)}{742 \cdot s^2 + 239 \cdot s + 1}$	$\tau = 175c$
0	$W_{u0}(s) = \dfrac{1}{3,6 \cdot s + 1}$	0

Table 2. Results of solving the problem of parametric optimization of the internal contour $i = 1$ of the cascade system

M1	1.05	1,10	1.15	1.20	1.25	1.30	1.35	1.40	1.5	1.6
Δ_{11}^{opt}	15	15	15	10	10	10	10	10	6	6
Δ_{12}^{opt}	48.8	30.6	22.3	16.5	13.8	11.9	10.42	9.29	7.27	6.23
Δ_{13}^{opt}	2.44	10.88	17.18	6.83	9.07	10.9	12.4	13.6	1.94	2.82

Table 3. Results of solving the problem of parametric optimization of the external contour $i = 2$ of the cascade system

M1	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70
Δ_{21}^{opt}	0.118	0.144	0.171	0.198	0.226	0.254	0.282	0.311	0.340	0.369
Δ_{22}^{opt}	1.421	1.467	1.511	1.554	1.595	1.634	1.671	1.708	1.742	1.776
Δ_{23}^{opt}	3.711	3.824	3.938	4.052	4.167	4.282	4,398	4.514	4,630	4,746
$I2(\Delta_2^{opt})$	0.072	0.074	0.075	0.077	0.079	0.080	0.082	0.084	0.085	0.087

Table 4. Results of solving the problem of parametric optimization of the local contour $i = 0$ regulation of steam flow into the furnace

M1	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70
Δ_{01}^{opt}	1.776	1,760	1.778	1.816	1.897	1.967	2.130	2.302	2.546	2.864
Δ_{02}^{opt}	0.474	0.316	0.198	0.105	0.033	-0.034	-0.081	-0.126	-0.164	-0.197
Δ_{03}^{opt}	10.953	11,530	12.274	13.173	14,330	15.609	17.401	19.499	22.216	25.727
$I0(\Delta_0^{opt})$	1.377	1.432	1.488	1.542	1.598	1.652	1.708	1.763	1.818	1.873

As an example, Figure 4 shows a graph of transient processes in the synthesized control system with optimal settings for the controllers during the initial start-up of the furnace at the time $t_1 = 0$ sec with reaching the specified fuel oil temperature $(Z_1 = (390^0 C)$ and the action of external disturbances: a change in the flow rate of superheated steam (through the channel $f_2 \rightarrow z_2$) at time $t_1 = 1500$ sec and a change in the flow rate of raw materials (through the channel $f_0 \rightarrow z_0$) at time $t_2 = 3000$ sec. [10]

The use of the DEA method for assessing the effectiveness of control showed that after parametric optimization, local ACS, which had the worst integral estimates of the quality of control processes, now received estimates equal to one, which means that they fully comply with the requirements for transient and steady-state operation of the ACS.
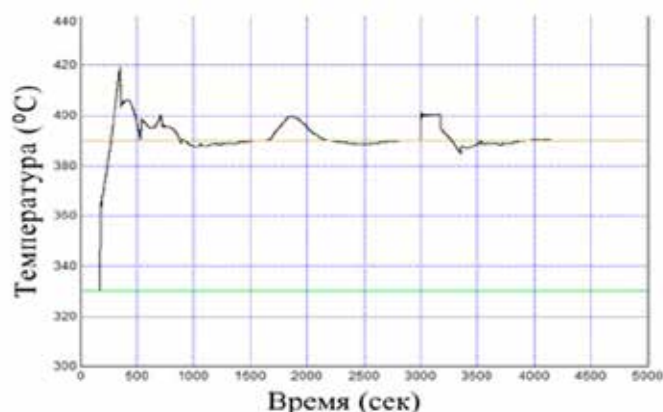
Figure 3 - Transient processes in the automatic control system with the temperature of the fuel oil of the AVT installation at M0=1.25, M1=1.6, M2=1.5

Conclusion. An analysis of a typical multi-stage process of primary oil refining as a complex technical object of control and optimization is given, which allows, based on the construction of system integral estimates of the relative efficiency of local control loops, inefficiently controlled technological parameters are identified and the corresponding multiply connected control systems are optimized.

1. The evaluation of the efficiency of control of typical oil refining processes using the proposed methods leads to the need for parametric optimization of multiloop control systems that do not meet the requirements for control quality.

2. The problem of optimizing cascade control systems is formulated and an algorithm for solving it developed on the basis of the alternance method is proposed, which allows to ensure the maximum degree of invariance of local control loops with respect to external disturbances under given restrictions on the maxima of the amplitude-frequency characteristics of closed local loops of the synthesized ACS along the channels of master influences.

3. The dynamics of control objects is described and the synthesis of mathematical models of local automatic control systems is presented in the form of transfer functions for the considered channels of action of master and disturbing influences on the example of automatic control system by the process of heating the raw material of the vacuum block of the AVT installation. [11]

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THE ROLE OF ARTIFICIAL INTELLIGENCE IN THE EDUCATIONAL PROCESS

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Abstract: Artificial intelligence automates key activities in education, such as assessment. Educational programs are adapted to the needs of students. Artificial intelligence programs provide useful feedback to students and teachers.

Keywords: artificial intelligence, big data, cloud computing, internet of things, intellectual systems.

Introduction. Science fiction writers, futurists, and filmmakers have long predicted that the rise of artificial intelligence will bring about significant, and possibly dangerous, changes. However, despite its widespread integration into our daily lives, AI has not caused any catastrophic events. Smart sensors, automatic parking, and personal assistants on smartphones are just a few examples of how AI has quietly become a part of our lives. Artificial intelligence means an intelligent artificial system that performs logical and creative human functions. The term can also be applied to any technology that exhibits characteristics associated with the human mind, such as learning and problem solving.

An ideal characteristic of artificial intelligence is the ability to evaluate and take actions that have the best chance of achieving a specific goal. The world of AI is almost limitless, and it's becoming more and more powerful thanks to growing engineering and computing capabilities.

An ideal characteristic of artificial intelligence is the ability to evaluate and take actions that have the best chance of achieving a specific goal. The world of AI is almost limitless, and it's becoming more and more powerful thanks to growing engineering and computing capabilities.

Various narrow functions, tasks and activities can already be performed at the level of human capacity and above, sometimes reducing the need for humans[1].

Literature review and methodolgy. The President of Uzbekistan issued a decree (No. PQ-4996) on 17 February 2021 to facilitate the rapid integration of artificial intelligence technologies. This decree is in line with the "Digital Uzbekistan - 2030" strategy, which aims to expand the use of AI and enhance access to digital data. The decree outlines several measures, including the promotion of scientific research to implement AI in various sectors, development of innovative products and automation software, and fostering cooperation with foreign institutions for joint projects[2].

Additionally, the decree calls for the creation of favorable conditions for training skilled professionals in the field of AI, forming a scientific ecosystem for the advancement of digital technologies, and introducing AI into the social and economic sectors and state management system. In web programming, Python allows you to create the entire backend of an Internet resource.

Backend is an internal component of the Internet resource. This is a database stored on a remote server computer. According to the user's request, information is obtained from such a database and transferred to the browser on his computer. And the data received here is processed by the second component of the site frontend. One area where this programming language is in high demand is machine learning. These technologies are closely related to artificial intelligence, neural networks and deep learning. Machines are already fully capable of learning when performing automated analysis of certain amounts of data. At the same time, the need for programming is minimized during machine learning. Many libraries are suitable for this task, such as Numpy, PyTorch, Pandas, etc. With their help, you can easily perform all mathematical calculations, because. they are able to do them automatically without human help. All that remains is to analyze the obtained results and choose the optimal solution for further tasks.

Results. AI may not replace teachers in the next ten years, but there are various ongoing projects utilizing

computer intelligence to enhance the educational experience for both students and teachers. These AI roles will be influential in shaping and defining the future of learning.

1. Artificial intelligence has the potential to streamline certain tasks in education, particularly assessment. Grading student work is often a tedious and time-consuming task for educators, leaving less time for lesson preparation, student interaction, and professional development. While AI will never fully replace human judgment, it has become increasingly capable of automating multiple-choice assessments and may soon be able to grade fill-in-the-blank and even student writing. Although essay grading software is still in its early stages and not yet completely reliable, it is likely to improve in the future, freeing up teachers to focus on more engaging classroom activities and personal interaction with students. By automating certain aspects of assessment, AI can help to alleviate the workload of teachers and enable them to provide more individualized attention to their students, ultimately improving the overall quality of education[3].

2. Education can be customized to meet the individual needs of students at all levels of education. AI is poised to significantly impact education by offering higher levels of personalized learning opportunities. One of the ways AI is already facilitating this personalized learning is through the implementation of flexible curricula, games, and software that cater to students' specific needs. These systems enable students to focus on topics that they need to improve on, review what they may not have fully understood, and work at their own pace. Personalized learning can help students of different levels to work together in the same classroom, with teachers serving as facilitators, and providing support as necessary. Adaptive learning has already made a significant impact on education in the United States, thanks in part to programs like Khan Academy. As AI technology advances over the coming decades, adaptive learning programs are expected to further improve and expand, providing students with even more opportunities for personalized learning[4].

3. Artificial intelligence can identify areas for improvement in teaching materials and lectures, which may not always be apparent to teachers, resulting in students becoming confused about certain concepts. Coursera, an online learning platform, is already utilizing this approach. When a large number of students answer a homework assignment incorrectly, the system alerts the teacher and provides a tailored message with hints on the correct answer for future students. This framework helps to bridge gaps in explanation that can occur in courses, ensuring that all students are building on the same foundational knowledge. By providing immediate feedback, students can understand a concept better and remember how to apply it correctly in the future, without having to wait for a professor to answer[5].

4. Artificial Intelligence-based tutoring programs are gaining popularity among students who need extra help. Although human tutors offer benefits that machines cannot yet replace, AI-based tutoring programs can teach basic subjects such as math and writing. However, they currently have limitations in helping students with higher-order thinking and creativity, which require human educators' assistance. This does not rule out the possibility of AI tutors providing these services in the future. With the rapid pace of technological advancements in recent years, advanced tutoring systems may become a reality soon[6].

5. AI-powered software can provide valuable feedback to students and educators, not only assisting in the creation of customized courses but also in evaluating the success of the entire course. Many schools, particularly those offering online education, use AI systems to monitor student progress and alert teachers when there are performance issues. These AI programs enable struggling students to receive the support they require and professors to identify areas where learning can be enhanced. These schools' AI systems offer more than just course recommendations; some are also developing systems to assist students in selecting majors based on their academic strengths and weaknesses. While students are not required to participate in counseling, it can open up new opportunities for potential students in terms of college options[7].

6. The impact of AI systems on the way we interact with information is often unnoticed, but it is significant. For instance, Google personalizes search results according to the user's location, while Amazon recommends products based on past purchases. Siri also adapts to user needs and commands, and web advertising is tailored to individuals' interests and buying habits. These intelligent systems will continue to shape how we interact with information in our personal and professional lives, and their influence may extend to how data is found and used

in academia and schools. With AI-based systems already having transformed the way we interact with data, the integration of more advanced technologies could lead to a new era of research and fact-finding for students[8].

7. New technologies, such as intelligent computing systems, can bring about changes in the role of teachers in education. While teachers will always be present in education, their responsibilities and significance may evolve due to the advancements of AI. As previously mentioned, AI can perform tasks like grading, provide learning assistance to students, and even replace human tutors. However, AI can be applied to many other aspects of teaching as well. For instance, AI systems can create learning experiences that allow students to ask questions and find information, or even substitute teachers for the most elementary course materials. Nonetheless, in most cases, AI supplements the role of teachers rather than replace them altogether. Teachers can complement AI classes, provide support to struggling students, and offer human interaction and hands-on experiences. This shift in the teacher's role is already happening in many schools, especially those that employ an online or flipped classroom approach[9].

8. AI-based systems can provide a less intimidating environment for trial and error learning, which is essential for the learning process, as some students fear failure or being put on the spot. AI educators can offer a non-judgmental learning experience and provide solutions for improvement, making it easier for students to learn. In fact, AI is well-suited for this type of learning since AI systems themselves often learn by trial and error[10].

9. AI-driven data has the potential to revolutionize the way schools identify, educate, and assist their students. With intelligent data collection facilitated by AI systems, universities can customize every aspect of the college experience to suit the unique needs and objectives of each student. This includes recruitment efforts and course selection, among others[11]. Data mining has already become an integral part of higher education, but AI could take this transformation to the next level. Some institutions have already introduced AI-based instruction to help students transition from high school to college. In the future, the college selection process could resemble that of Amazon or Netflix, recommending the best schools and programs based on students' preferences and interests.

10. Artificial intelligence has the potential to completely transform education by changing the location of learning, the individuals who teach students, and the methods students use to acquire essential skills. Even though major changes may take several years, AI systems can revolutionize every aspect of education. With the use of AI-powered software and support, students can learn from any location at any time, thereby replacing certain forms of classroom instruction. However, in some cases, AI may even replace teachers[12]. Currently, AI-based education programs help students learn basic skills, but as these programs expand and developers gain more knowledge, they can offer more services to students. The educational process may be completely different in a few decades with the integration of AI technology.

Conclusion. In the future of education, teachers and machines will work hand-in-hand to help students learn more effectively and efficiently. As artificial intelligence takes over tasks like testing and grading, personalized curriculum development, and emotional understanding of students, teachers will be able to focus on teaching social skills and acting as coaches. This shift in roles will allow teachers to provide emotional support and guide students towards their goals. Additionally, AI-powered education can provide better learning opportunities for students in remote areas and offer personalized online learning options. With widespread internet access, students in developing countries and remote locations can access high-quality education previously unavailable to them. Overall, the implementation of AI in education has the potential to transform the role of teachers and improve educational access and outcomes for students worldwide.

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FEATURES OF HANDWRITING IMAGE PROCESSING AND ANALYSIS

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Abstract. During the digitization stage, the manuscript text may be corrupted or in some cases interfered with due to technical or human factors. In addition, in some cases the source itself (for example, an ancient manuscript) is in poor condition.

Keywords: Geometric distortion, uneven lighting, contrast variation, ink bleed distortion, faded ink, staining, paper ghosting, blurring, fine or faint text, poor quality documents.

Introduction. Non-text elements include ink stains, paper stains, pictures, etc. that were not removed during the binarization process. Their extraction can be done, for example, by extracting the connection components in the image, calculating geometric features and classifying the connection component as part of the text or as a defect using machine learning or heuristic methods.

At the stage of identifying segmented text features, a set of features is formed that allows solving one or another problem of the analysis of the manuscript text, and it depends on the practical problem to be solved. Thus, when solving the problem of recognizing a handwritten text, features of handwritten signs that are common to one character are determined, and when determining the author of a handwritten text, features specific to the author of the text are determined.

In the character space formed at the stage of recognition, recognition is carried out based on one or another recognition method.

Literature review and methodology. At the moment, the task of automating the process of analyzing handwritten text images has not been fully solved. One of the most important stages is the preliminary processing of manuscript images, which is underdeveloped.

This article examines such interferences, which are common in practice, and the available algorithms for their elimination or reduction.

Geometric distortion. In the digitization of manuscript text images, sources such as changes in the lens of the digitizing device and distortion of the geometric similarity of the image with respect to its original appear.

The main types of initial image distortion include distortion (pillow and barrel distortion), warping, and perspective. One of the ways to eliminate such distortions is to reduce the nonlinear predistortion of the raster during image spreading, which allows to compensate for the expected distortions. In addition, the distorted raster can be a posteriori corrected based on a polynomial approximation of each horizontal and vertical line. The approximations are then used to calculate the inverse correction functions for each grid cell. The spatial curvature method allows to eliminate perspective distortions. By tilting the image of an elongated object viewed from the side, it can be made to appear as an image viewed at a right angle. Another important application of this method is to correct paired images of the same scene taken at different viewing angles.

Uneven lighting. Due to incident light in an optical medium, the scattering of image particles in the light path decreases exponentially, and as a result, the image

quality obtained by light microscopy deteriorates and defects such as uneven illumination appear [1]. As a result of light absorption and scattering, light spectra change and it causes background objects to be unevenly illuminated [2]. Uneven illumination of background objects causes various problems in document image analysis. If the lighting in the handwritten text images is uneven, the recognition of the texts in the image will often lead to ineffective results. In general, high-accuracy text recognition involves converting the grayscale image to a binary image and extracting the text. At the same time, due to uneven illumination, the binary image has artifacts, which causes incorrect extraction of text from the regions of these artifacts.

Contrast variability. Contrast is defined as a change in brightness. In most cases, contrast refers to the difference between high and low intensity pixels in an image. In addition, contrast can be obtained as the difference between the pixel values of the top or bottom of the object and the background in the image [3]. Factors such as interference environment, sunlight, illumination and occlusion often lead to contrast variability [4]. Contrast variation in handwritten text images causes various problems in extracting the foreground text from the background of document images and using traditional thresholding methods and algorithms in their analysis. Such problems are overcome by applying image quality improvement techniques before image binarization.

Disruption due to ink leakage. Ink smears or ink bleeds occur when text is written on both sides of the paper, or when ink used on one side begins to show on the other side of the paper. The presence of ink leakage in the binarization of handwritten text images leads to increased interference. The ink spreads from one side of the page to the other, causing the quality of the text there to deteriorate. Many ideas have been proposed to prevent such disruptions, and researchers have faced two major challenges. The first problem is a corrupted document digitized in high resolution. This is except for cases involving a digitization project or a library. The second problem is found in all methods of recovery. This is due to the fact that the original and complete sample of historical document records is not available in the quantitative analysis of the results [5]. This problem can be solved by preparing a specific image with quality distortion based on the original truth [6] or by improving the image quality by knowing the original truth in the distorted images

[7]. Although reliability is not available, efficiency can always be analyzed. It is necessary to determine the quantitative effect of the recovery result for the next stage. For example, characters in a handwritten text image can be evaluated by analyzing the output of optical recognition systems.

Faded ink or faded characters. There is considerable historical, social and political interest in analyzing large numbers of official documents and placing them in digital libraries and archives, where most of the official documents are typed. This creates various problems related to their recognition [8]. Each individual character in a document may appear thinner or thicker compared to other printed documents or characters around it. It directly depends on the printing part of the particular character button on the machine and its pressing force.

Second, most machine-printed documents survive only as copies printed on very thin paper (Japanese paper) with a unique texture. In addition, most machine-printed copies of documents (originals and carbon copies require a harder key press) are blurred [9]. Problems such as reuse and wear, tears, stains, paper clip rust, holes, document fragmentation, and discoloration adversely affect the quality of machine-printed historical documents.

View behind painting or paper. After the digitization of manuscripts, many problems arise due to distortions in images and low resolution digitization. Such problems have a negative impact on the visual appearance of the image [10]. Historical manuscripts can have various forms of corruption. All the disorders in them depend on the passage of time and have a different nature [11]. However, one of the biggest problems with documents is the quality degradation caused by one-sided writing being reflected on the back of the paper. In the past, many documents were written on both sides of the paper [12]. This problem occurs when the ink on one side shows through on the other side, making the document difficult to read. Such disruptive documents need to be restored to make them easier to read. Solving the problem of the appearance of ink behind the paper allows you to significantly reduce the time of image compression and download them faster over the Internet. If such distortions in the image are eliminated, a clear background can be achieved [10].

Fading. There are two types of blur in handwritten text images, motion blur and focus blur. In general, motion blur artifacts are caused by the relative speed

between the camera and the subject, or sudden rapid camera movement. Out-of-focus blur occurs when the light beam fails to converge on the image. Research topics in solving the blurring problem are implemented using blurring evaluation tools in images to evaluate the accuracy of optical character recognition, thereby allowing the user to obtain new images and provide the opportunity to achieve the required recognition accuracy.

Fine or weak text. Manuscript documents written in the past consisted of very thin or faint text, written mostly in ink and sometimes through paint. Fading of the ink or paint used in the writing of historical manuscript documents results in a deterioration of the image quality of the manuscript. In other cases, the use of low-quality ink and the nature of the paper used will cause thin or weak text. This complicates the application of binarization methods and text recognition. Nowadays, researchers are more interested in the analysis of historical manuscript text images, which poses various challenges. Distortions in historical documents, such as delicate or weak texts, are prompting researchers to develop image enhancement and binarization algorithms that provide good enough results to solve these problems [13]. Based on the binarized images, successive steps such as joint displacement detection, page or line segmentation were created later.

Degraded documents. Typically, original documents written on paper come in a variety of media (ink, graphite, watercolor) and formats (maps, spreadsheets, and notebooks). Such documents may contain informational, evidential, associative and significant information of intrinsic value [3]. A document consisting of historical, legal or scientific information is considered to be of great evidentiary value if the original state of the media format and image has not undergone a drastic change or quality has not deteriorated [5]. Nevertheless, the careless use of documents is not the only factor that leads to the loss of their parts, deterioration of quality and various damages [3]. Factors such as poor storage and poor use and environmental conditions also affect the quality of documents. In addition, serious damage and quality deterioration can also be caused by environmental factors.

Results. To achieve this goal, it is necessary to perform the following tasks:

- analysis of the modern state of problems of processing and recognition of handwritten text images;

- researching the problem of quantitative assessment of the quality of the original image of the handwritten text;

- separation of periodically repeating straight lines in the image;

- handwritten text image binarization;

- segmentation of handwritten text lines and words in the image;

- experimental research and evaluation of the effectiveness of algorithms created for preliminary processing of handwritten text images;

- creation and practical application of a set of preprocessing programs for handwritten text images.

Conclusion. The main practical problems to be solved based on the analysis of handwritten text images were studied. In this case, it was proved that the initial processing stage of given images is important in the creation of systems for the analysis of handwritten text images and has a significant impact on the final results of the system.

Specific features of processing and analysis of handwritten text images are identified and the main problems are described. Algorithms that allow solving the stated problems were analyzed. As a result of the analysis, their achievements and shortcomings were determined. It was found that the existing algorithms completely or partially solve some of the identified problems. This situation shows the need to develop and research algorithms for pre-processing of handwritten text images.

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PUBLIC, PROTECTED, PRIVATE MEMBERS IN PYTHON

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Abstract: This article focuses on the public, protected, and private view members in the Python programming language and provides information and examples of how to manage view rights in the Python programming language without using these keywords.

Keywords: Python, programming, encapsulation, polymorphism, inheritance, public, private, protected, class, self, property.

Introduction. In Python, class members can be classified into three categories: public, protected, and private. These access modifiers determine the visibility and accessibility of the class members to other parts of the program.

Public members are accessible from anywhere in the program, both inside and outside the class. They can be accessed using the dot operator after creating an instance of the class.

Protected members are not accessible from outside the class, but they can be accessed from within the class and its subclasses. In Python, this is achieved by adding a single underscore before the name of the member.

Private members are not accessible from outside the class or from its subclasses. In Python, this is achieved by adding two underscores before the name of the member.

Understanding the difference between public, protected, and private members is important in object-oriented programming, as it allows for better control over the visibility and accessibility of class members. This can help in improving the overall design and security of a program.

Literature review and methodology. Python is a dynamically typed programming language [1, 2]. Python is an object-oriented programming language. But unlike many object-oriented languages, in Python, the scope of an object's use is determined by its current set of methods and fields, as opposed to inheriting from a specific class. The approach used in Python is called "duck typing". The name of the term

comes from the English "duck test" ("duck test"), which in the original sounds like "If it looks like a duck, swims like a duck and quacks like a duck, then it probably is a duck" ("If it looks like a duck, swims like a duck, and quacks like a duck, then it's probably a duck") [3]. In Listing 1, the parse_node() function takes several parameters; Python does not specify the types of the parameters. Referring to parameter methods in the function body will be correct if the objects passed as parameters have these methods. This means that if the visitor object class has the prepare() and visit() methods defined (it "behaves like a duck"), then accessing them will succeed (it is considered that "it is a duck"). If, for example, the visit() method is not defined for the object class, then the interpreter will generate an exception AttributeError: A instance has no attribute 'visit' if visitor is an object of class A.[4]

Many practical problems of our time in economics, architecture, electronics and other fields of science at a certain stage of development require the solution of complex problems consisting of many interrelated parts. To solve them, a systematic approach is used, which allows you to get a single answer that takes into account all subtasks. But when the question concerns a formalized mathematical version of the problem of optimizing a solution for many factors and criteria at the same time, then the number of relatively general methods that give a single answer is very small. By constructing hypersurfaces corresponding to the output data of the experiment, their sections by level hyperplanes and their intersections, the optimization

area is reduced to the minimum possible dimension for subsequent selection among equivalent points by the user.

To implement the algorithm, the Python programming language was chosen, since it has wide capabilities for working with data arrays, is easy to learn and portable to any devices and systems. The software library includes two working classes: the main class is used for the optimization operation and working with database tables; auxiliary contains three basic groups of methods for processing sets of points and curves on a plane. The optimization methods of the main class of the library allow two main operations to be carried out: a section by a level plane and a search for the intersection of two hypersurfaces in spaces with the same dimensions. In the first case, one database table and a given height value for the level plane are used. On the basis of a complete enumeration of the values of the table, the contour curves of the hypersurface are constructed in all two-dimensional planes, except for those parallel to the section, which are subspaces of the workspace and fill the regular grid of table values. For each curve, the points of intersection with the projection of the section plane are found and stored in a new table representing the result of the section in the new dimension space one less than the original one. The intersection of two surfaces, unlike the first method, requires working with two source tables in the same dimensions. The resulting table is filled with the values of the intersection points of the contour curves of two hypersurfaces and has the dimension equal to the original one.[5]

Encapsulation is one of the fundamental principles of object-oriented programming (OOP). It refers to the practice of hiding the implementation details of an object from the outside world, and instead providing a public interface through which other code can interact with the object.

In Python, encapsulation can be achieved through the use of access modifiers, which control the visibility of class attributes and methods. There are two main types of access modifiers in Python:

Public: attributes and methods that are accessible from outside the class. These are not prefixed with any special characters, and can be accessed using the dot notation.

Private: attributes and methods that are only accessible from within the class itself. These are prefixed with a double underscore (e.g. "__my_

private_attribute"), and can only be accessed using special name mangling syntax (e.g. "_ClassName__my_private_attribute").

Here's an example of how encapsulation can be implemented in Python:

Listing 1. An exampleEncapsulation in Python
```python
class Car:
    def __init__(self, make, model):
        self.__make = make
        self.__model = model

    def get_make(self):
        return self.__make

    def get_model(self):
        return self.__model

    def set_make(self, make):
        self.__make = make

    def set_model(self, model):
        self.__model = model
```

In this example, the attributes "make" and "model" are declared as private using the double underscore prefix. The class provides public getter and setter methods for these attributes, which allow other code to access and modify them indirectly. By doing this, the implementation details of the Car class are hidden from the outside world, and the code is better organized and easier to maintain.

Results. Public Members. Public members (generally methods declared in a class) are accessible from outside the class. The object of the same class is required to invoke a public method. This arrangement of private instance variables and public methods ensures the principle of data encapsulation.

All members in a Python class are public by default. Any member can be accessed from outside the class environment.

Listing 1: Public Attributes
```python
class Student:
    schoolName = 'XYZ School' # class attribute

    def __init__(self, name, age):
```

```
    self.name=name # instance attribute
    self.age=age # instance attribute
```

You can access the Student class's attributes and also modify their values, as shown below.

Example: Access Public Members
```
>>> std = Student("Steve", 25)
>>> std.schoolName
'XYZ School'
>>> std.name
'Steve'
>>> std.age = 20
>>> std.age
20
```

Protected Members. Protected members of a class are accessible from within the class and are also available to its sub-classes. No other environment is permitted access to it. This enables specific resources of the parent class to be inherited by the child class.

Python's convention to make an instance variable protected is to add a prefix _ (single underscore) to it. This effectively prevents it from being accessed unless it is from within a sub-class.

Listing 2: Protected Attributes
```
class Student:
    _schoolName = 'XYZ School'
# protected class attribute

    def __init__(self, name, age):
        self._name=name  #
protected instance attribute
        self._age=age #
protected instance attribute
```

In fact, this doesn't prevent instance variables from accessing or modifying the instance. You can still perform the following operations:

Example: Access Protected Members
```
>>> std = Student("Swati", 25)
>>> std._name
'Swati'
>>> std._name = 'Dipa'
>>> std._name
'Dipa'
```
However, you can define a property using property decorator and make it protected, as shown below.

Listing 3: Protected Attributes
```
class Student:
    def __init__(self,name):
        self._name = name
@property
def name(self):
        return self._name
@name.setter
def name(self,newname):
        self._name = newname
```

Above, @property decorator is used to make the name() method as property and @name.setter decorator to another overloads of the name() method as property setter method. Now, _name is protected.

Example: Access Protected Members
```
>>> std = Student("Swati")
>>> std.name
'Swati'
>>> std.name = 'Dipa'
>>> std.name
'Dipa'
>>> std._name # still accessible
```

Above, we used std.name property to modify _name attribute. However, it is still accessible in Python. Hence, the responsible programmer would refrain from accessing and modifying instance variables prefixed with _ from outside its class.

Private Members. Python doesn't have any mechanism that effectively restricts access to any instance variable or method. Python prescribes a convention of prefixing the name of the variable/ method with a single or double underscore to emulate the behavior of protected and private access specifiers.

The double underscore __ prefixed to a variable makes it private. It gives a strong suggestion not to touch it from outside the class. Any attempt to do so will result in an AttributeError:

Listing 4: Private Attributes
```
class Student:
    __schoolName = 'XYZ School'
# private class attribute

    def __init__(self, name, age):
        self.__name=name  #
```

```
private instance attribute
        self.__salary=age #
private instance attribute
    def __display(self):  #
private method
        print('This is
private method.')
```

Example: Access Private Members and Errors
```
>>> std = Student("Bill", 25)
>>> std.__schoolName
AttributeError: 'Student' object
has no attribute '__schoolName'
>>> std.__name
AttributeError: 'Student' object
has no attribute '__name'
>>> std.__display()
AttributeError: 'Student' object
has no attribute '__display'
```

Python performs name mangling of private variables. Every member with a double underscore will be changed to _object._class__variable. So, it can still be accessed from outside the class, but the practice should be refrained.[6]

Example: Access Private Members in Python
```
>>> std = Student("Bill", 25)
>>> std._Student__name
'Bill'
>>> std._Student__name = 'Steve'
>>> std._Student__name
'Steve'
>>> std._Student__display()
'This is private method.'
```

Conclusion. Python is a modern fast-growing programming language that continues to grow in technology market share. So, according to the monthly ranking of the popularity of programming languages PyPL, created on the largest web service of projects Github, based on search queries on the Internet, Python takes the first place at the time of June 2022 with 27.61% of the total number of requests related to programming languages. One of the reasons for the popularity of the Python programming language is that this programming language has a large number of additional specialized software libraries designed to process and analyze large amounts of data. [7]

Thus, in the Python programming language, members with public, protected, and private views can be used. But the use of these members is quite different from how it is in programming languages like C#, Java, C++. This aspect is also another priority of the Python programming language.

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IMPORTANCE OF PYTHON LANGUAGE IN DEVELOPMENT OF ARTIFICIAL INTELLIGENCE

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The introduction of artificial intelligence technologies in various fields has become an urgent demand at the current pace of society's development. The integration of various intellectual technologies is a key factor in this era. The article examines the use of the Python programming language in the implementation of artificial intelligence technologies.

Keywords: artificial intelligence, big data, machine learning, deep learning, Python libraries, intelligent systems.

Introduction. The most dangerous aspect of the modern world based on artificial intelligence is that it is based on the principle of "Winner Takes All". This is a factor that increases social tension and international conflicts. In the international arena, the competition for the database is expanding, as is the struggle for oil and other fuel resources.

The main factor of development in the globalized world is determined by technical and technological progress. Also, the scientific and technological network, economy and security have been developing synchronously, interacting with each other for several centuries. Today, a new factor in social and economic life - artificial intelligence - has rapidly entered and actively participates in our daily life. For example, Google can remember and recommend the most searched commands. Corporations collecting such huge data are actively interfering in political, social and economic processes by reanalyzing it. Database control has become a major goal of many governments[1].

Artificial intelligence means an intelligent artificial system that performs logical and creative human functions. The term can also be applied to any technology that exhibits characteristics associated with the human mind, such as learning and problem solving. An ideal characteristic of artificial intelligence is the ability to evaluate and take actions that have the best chance of achieving a specific goal.

The world of AI is almost limitless, and it's becoming more and more powerful thanks to growing engineering and computing capabilities. Various narrow functions, tasks and activities can already be performed at the level of human capacity and above, sometimes reducing the need for humans[2].

According to research, in the next fifteen years, AI technologies will have a greater impact on society than any other possible advancement and will bring about changes on the scale of a global revolution. This is characterized by two different impact segments: first, AI technologies will have a significant impact on companies and employment. In this regard, groups of closely connected companies and organizations that make decisions based on big data will emerge, which will lead to increased global competition between them. Second, humans will be able to enjoy unlimited additional benefits thanks to artificial intelligence.

Some cases that have occurred in the system of international relations in recent years show that military security and defense systems are becoming directly and indirectly dependent on AI technologies. In particular, with the withdrawal of US troops in 2021, the change in the political balance did not occur only in Afghanistan. A similar process took place in Iraq. This international trend is also explained by the migration of political and economic centers. More importantly, these changes took place not only from a geographical point of view, but also from a technological point of view. The discovery of drones and their successful use in several operations has shown that it is no longer beneficial for the United States to maintain bases in many regions that cause large costs. If a military operation in Afghanistan or Iraq becomes necessary, Washington is sure that it can

do it with the help of unmanned vehicles launched from Qatar. As Z. Brzezinski noted in "The Great Chessboard", maintaining troops in Afghanistan or Iraq in the modern world has lost its importance for the United States even to compete with Moscow or Beijing. The reason for this is explained by the fact that the field of competition has moved from land, sea or air spaces to cyberspace or outer space. As soon as keeping large contingents on the ground lost its relevance, the US and other Western countries began to gradually evacuate their troops. The reduction in the number of ground troops in war zones requires armies to rely more on cutting-edge digital technologies, including artificial intelligence[3].

AI has the potential to reduce human involvement in warfare. First, AI can transform the allocation of human and machine resources needed to engage in war and war-related operations. Second, artificial intelligence affects the speed of operations, which paradoxically reduces decision-making time. Arguably, no new military technology has received more attention from experts than drones over the past decade, as drones rise to prominence as the most prominent technological tool in modern information age warfare.

The trend observed in recent military operations also prompted a fundamental change in strategic priorities. In the short-lived war between Azerbaijan and Armenia in the fall of 2020, the Azerbaijanis destroyed Armenian tanks using cheap, unmanned drones supplied by Turkey. These devices hit the target without endangering the operator's life. According to some experts, it was in the Karabakh war that the influence of drones gained importance at the level of "changing the tactical game"[4].

As drones drastically reduce the human factor and financial costs, states will be more likely to go to war in the future. This means that if the drone revolution is to take place, countries will have to significantly rethink their defense policies. Combat unmanned drones were once the main "chip" of military powers, but today small countries are increasingly trying to acquire them. Throughout the military history of mankind, there were periods when a single weapon system became a symbol of the entire war era. The long bow used by English archers in the Middle Ages confused other enemy forces. Also, the role of technological innovation has been significantly important in the military success of the United States. During the American Civil War, US President Abraham Lincoln used the modern telegraph system to communicate with his military, coordinate strategy, and move troops.[5]

Literature analysis and methods. Even today, the introduction of AI technologies in the field of defense is seen as a revolution. This revolution is different from the previous military revolutions due to the fact that AI technologies will be used first in the social spheres, and then in the military spheres. Weapons with previous military technological potential, such as nuclear weapons, are characterized by the fact that they were first used in the military sphere and later integrated into the networks of everyday life. This also made it possible to save funds for research in the field of defense during this period. Like the secret weapons of Hitler's Germany before World War II, drones or robots based on artificial intelligence have the potential to change the balance of the world. Therefore, research in this field of technology should be transparent, and the weapons developed should be limited by international law, as in the nuclear weapons regime. Because increasingly advanced technologies can increase threats to the future of humanity [6].

• Closely related technologies, such as artificial intelligence and various machine learning algorithms, have become major topics of discussion both among experts and in society at large. The Python language is widely used for the development of artificial intelligence. Some general information and interesting facts about the language and its creator:

• The creator of the Python language is the Dutch programmer Guido van Rossum. In our time, the beginning of work on such a popular language began by chance. "In December 1989, I was thinking about what to do during the Christmas holidays. The office was closed. So I started to improve my ABCs at home. I didn't even think that something else serious would happen during the work." Guido later recalled.

• The name of the language has nothing to do with reptiles. Guido van Rossum named his work after the Monty Python series. In addition, this name follows the tradition of naming programming languages after famous people.

• In creating Python, van Rossum followed principles that have had a significant impact on the software industry. He used simplified English (a foreign programmer can't spend a lot of time improving his English) as a supporter of open source. Finally, van Rossum strove for code brevity and ease of use.

• There are 19 sets of words that capture the spirit of the language - the Zen rules of Python. It is hosted on the official Python website. Zen of Python also opens in the Python console application when you enter the import command.

• In recent years, Python has become the most popular language taught in schools in many countries. 6 out of 10 parents surveyed would rather have their children learn Python than French.

• Python is one of the few programming languages that has been declared the official language of Google due to its efficiency.

• Since way back in 1989, Python has found a distinct spread in three areas:

• web development;

• processing of large data arrays (Big Data), machine learning, data analysis and visualization;

• create automation scripts.

In web programming, Python allows you to create the entire backend of an Internet resource. Backend is an internal component of the Internet resource. This is a database stored on a remote server computer. According to the user's request, information is obtained from such a database and transferred to the browser on his computer. And the data received here is processed by the second component of the site frontend.

Discussion. The use of Python has expanded thanks to the Django and Flask frameworks written in this language. Framework is a software shell that simplifies and speeds up the solution of common tasks. Examples of resources created in Django are Instagram, Disqus, Mozilla, The Washington Times, Pinterest. The Flask framework was used to create influential resources such as LinkedIn, Netflix, and Uber .

Also, the use of Python has shown itself well in writing analyzers - programs for collecting and organizing data placed on sites. Collecting data from various sites is called web scraping. The process is often used by analysts of various profiles in their work. But today, information is all around us, so it needs to be collected by experts in many professions. Python offers the programming language as a tool to facilitate this process. Web scraping is an automatic bot capable of quickly and reliably copying large streams of data from sites and pasting them into a specific table. Web scraping with Python is easy to do and the benefits are huge. Imagine that now you don't need to collect manually and spend several hours

in a row, everything is available automatically. Get millions of data points from the internet in minutes and use it to your advantage. And if the flow is small, web scraping can do the job in seconds.

Another area where Python is in demand is scripts for automating routine processes. A script is a short program containing a certain sequence of actions. A good example of a script is the macros in Google Sheets. Another example of using a script is email processing.

One area where this programming language is in high demand is machine learning. These technologies are closely related to artificial intelligence, neural networks and deep learning. Machines are already fully capable of learning when performing automated analysis of certain amounts of data. At the same time, the need for programming is minimized during machine learning. Many libraries are suitable for this task, such as Numby, PyTorch, Pandas, etc. With their help, you can easily perform all mathematical calculations, because. they are able to do them automatically without human help. All that remains is to analyze the obtained results and choose the optimal solution for further tasks.

In Chinese art, there is such an amazing artifact as the "Canton Ball". It is a sphere carved from ivory with several other spheres inside. In addition, each of the spheres rotates freely relative to its neighbors. We will arrange the discussed technologies in the following order: artificial intelligence -> machine learning -> neural networks -> deep learning.

The outer circle of such an imaginary canton ball would be artificial intelligence. Each subsequent technology on our list is built on the same as the previous one. Thus, machine learning is a part of artificial intelligence. Deep learning is a part of machine learning and neural networks are the basis for deep learning algorithms. Therefore, artificial intelligence is closely related to machine learning. Progress in the field of artificial intelligence is highly dependent on the availability of convenient and powerful programming tools.

Thus, Python has the best support for machine learning among all programming languages in its arsenal. This "miracle weapon" is TensorFlow, Keras, Scikit-learn artificial intelligence libraries specially created for machine learning. A library is a set of functions that allow you to solve a specific task in a program. The library saves the programmer from repeatedly "reinventing the wheel", that is, writing

code for routine, repetitive tasks. For example, the most common learning algorithms are already built into Scikit-learn.

The following fact speaks about the role of Python language in the development of artificial intelligence. According to Google Trends, in recent years interest in the field of machine learning, and indeed in the Python language, has skyrocketed worldwide. This event came a year after the release of the TensorFlow machine learning library[7].

The Python programming language has a simple and easy-to-understand syntax (a set of rules that define what arrangement of characters creates a valid expression). A large team of programmers formed around him, developing and popularizing the language. That is, on the one hand, development requires the use of artificial intelligence in all areas of life, on the other hand, there are a large number of specialists who can solve these problems using the Python language. Programming with the use of artificial intelligence also gives good results in the formation of e-commerce processes. The development of non-traditional commerce has a positive effect on the structure of the labor market of Uzbekistan. Industrialization of advanced information technologies will create thousands of new jobs. The stabilization of the economy of Uzbekistan, the strengthening of the competitiveness of goods and services, and the development of e-commerce at the same time will lead to an increase in the export potential of our country. Electronic commerce ensures the improvement of the standard of living of the population, the development of fields such as marketing and management.[8]

E-commerce web pages can be created in different directions. It can be created using ready-made platforms. Examples of ready-made solutions include WooCommerce plugin on WordPress platform, VirtueMarket platform on Joomla platform, OpenCart platform, OcStore platform, 1cBitrix and many others. The advantages of these platforms are that users without experience in web programming will be able to create their own online magazines without too much difficulty.[9]

When the created online magazine is required to be professional, it is necessary to turn to web programming. As one of them, the Django framework working in the Python programming language can be cited as an example.[10]

Results. Applying artificial intelligence in software requires an existing database. Currently popular voice assistants such as Yandex Alisa and Microsoft Siria can easily start a conversation with people. In order for them to be able to start a conversation, as mentioned above, a previously formed audio database is useful. When the user asks the AI a question, the voice is analyzed and converted into text. The most optimal of the possible alternatives for the generated text is selected and the audio response for this option is returned to the user. As you can see, this process is actually not very complicated[11]. Important aspects in this process are:

- the user's audio, i.e., converting it into error-free text if the speech is viewed as audio;

- semantic analysis of the finished text, if necessary, analysis of what is being said on the basis of previous dialogues with the user;

- creating a list of possible answers to this text;

- choosing the most optimal answer based on the dialogue;

- return the appropriate sound from the audio database to the user for the selected response text

Until now, such an audio database has been formed in developed countries, in particular, in English, French, German, Russian and other languages. But there is no Uzbek language database in this regard. It can be said that artificial intelligence programs in the Uzbek language are not developing precisely because of the lack of a database.
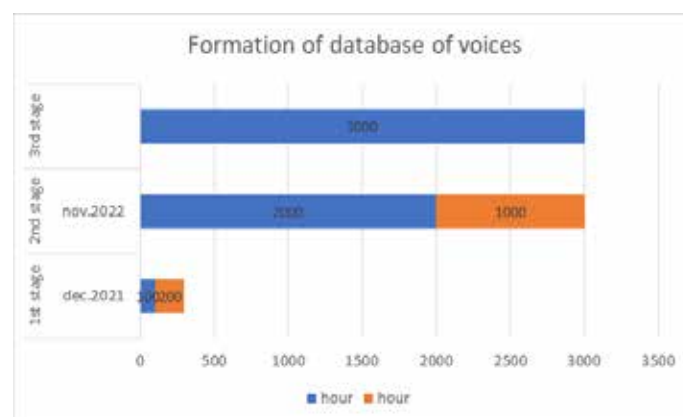

Figure 1. Sound database formation graph

According to the latest information, the newly established Uzbekvoice.ai team has started to solve the above problem (Fig. 1). The database of sounds is open source and anyone can use it in their project. Uzbekvoice.ai team completed the 1st stage in December 2021. The goal was to collect 100 hours of audio data. As a result, more than 200 hours of audio data were collected. In Phase 2, the goal was to

collect 2,000 hours of voice data and it was completed on November 13, 2022. As a result, more than 1000 hours of audio data were collected. Next is the 3rd stage. The goal of Phase 3 is to collect 3,000 hours of audio data. In order to use the voice database, a database of 10,000 hours should be formed[12].

People who know any Uzbek language can participate in the formation of the voice database. For this, you need to register on commonvoice.mozilla.org and select the Uzbek language from there. The interface shows only two options. The first is to read the text and write it down, and the second is to listen to the voice and compare it with the text. In order not to bore users, the tasks are divided into 5.
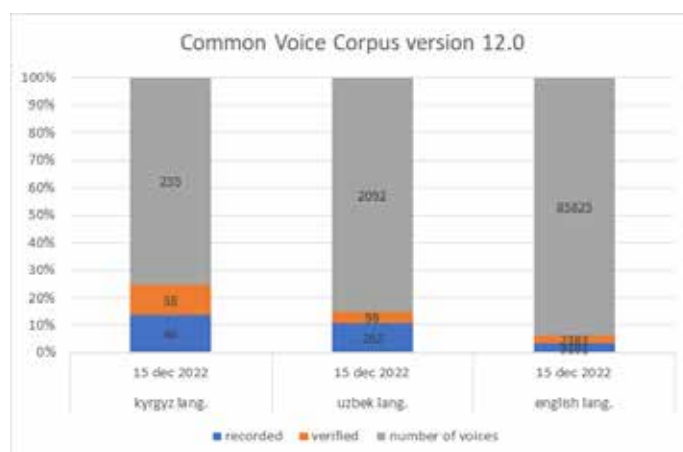

Figure 2. Common Voice Corpus version 12.0

In the download section of the dataset, the following information can be provided for comparison (Fig. 2): Total recorded hours in the Kyrgyz language according to the interpretation of "Common Voice Corpus 12.0" as of December 15, 2022 - 46 hours, the number of hours checked - 38 hours, and the number of votes is 255. This situation is as follows in the Uzbek language: according to the interpretation of "Common Voice Corpus 12.0" as of December 15, 2022, the total number of recorded hours is 262 hours, the number of recorded hours is 99 hours, and the number of voices is 2092. When we compared this situation to the English language, we saw the following results: according to the interpretation of "Common Voice Corpus 12.0" as of December 15, 2022, the total number of written hours is 3161 hours, the number of hours checked is 2383 hours, and the number of voices is 85,825.

According to the Uzbek language database "https://commonvoice.mozilla.org/uz/languages", 38% have been checked. There are 148,606 sentences in the database. Comparing this data to the English data, 75% were checked and there were 1,659,715 sentences.

Conclusion. In conclusion, the most dangerous aspect of the modern world based on artificial intelligence is that it is based on the principle of "Winner Takes All". This is a factor that increases social tension and international conflicts.

Also, the competition for the database will expand in the international arena, such as the fight for oil and other fuel resources. And it is not surprising that cyber security has become part of the integrity of countries.

There are several things that need to be done in the development of artificial intelligence in the Uzbek segment. In particular, it is necessary to develop and enrich the database of sounds like the above. As far as possible, it is necessary to make artificial intelligence think like a human. An artificial intelligence capable of thinking in Uzbek will be necessary to be able to make the right decision. It will be possible to use this artificial intelligence in various suitable fields later.

Artificial intelligence has become an almost exclusive use of the Python programming language in the last 5-10 years. Although the language itself appeared in the last century. A combination of factors contributed to this development:

• the need to process and analyze a large amount of data has arisen for the development of civilization. It is impossible to answer this problem without machine learning and artificial intelligence technologies;

• At that time, the Python programming language acquired all the necessary tools for solving problems in the field of Artificial Intelligence;

• ease of learning and ease of use have made this language popular among programmers. And a whole army of people ready to work in the field of Artificial Intelligence has been formed.

All these factors, which have resonated in recent years, have made the Python language and artificial intelligence technologies almost inseparable concepts in society's perception.

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