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Xalqaro miqyosidagi ilmiy-texnik anjuman materiallarida zamonaviy kompyuter ilmlari va muhandislik texnologiyalari sohasidagi innovatsion tadqiqotlar aks etgan.

Globallashuv sharoitida davlatimizni yanada barqaror va jadal sur’atlar bilan rivojlantirish bo‘yicha amalga oshirilayotgan islohotlar samarasini yaxshilash sohasidagi ilmiy-tadqiqot ishlariga alohida e’tibor qaratilgan. Zero iqtisodiyotning, ijtimoiy sohalarni qamrab olgan modernizatsiya jarayonlari, hayotning barcha sohalarini liberallashtirishni talab qilmoqda.

Ushbu ilmiy ma’ruza tezislari to‘plamida mamlakatimiz va xorijlik turli yo‘nalishlarda faoliyat olib borayotgan mutaxassislar, olimlar, professor-o‘qituvchilar, ilmiy tadqiqot institutlari va markazlarining ilmiy xodimlari, tadqiqotchilari, magistr va talabalarning ilmiy-tadqiqot ishlari natijalari mujassamlashgan.

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Mazkur to‘plamga kiritilgan ma’ruza tezislarining mazmuni, undagi statistik ma’lumotlar va me’yoriy hujjatlarning to‘g‘riligi hamda tanqidiy fikr-mulohazalar, keltirilgan takliflarga mualliflarning o‘zlari mas’uldirlar.

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DIGITAL REHABILITATION PLATFORM FOR CHILDREN WITH DISABILITIES

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Abstract: Children with disabilities often require long-term, multidisciplinary rehabilitation involving medical, psychological, educational, and social interventions. At the same time, their mothers or primary caregivers experience continuous physical, emotional, informational, and organizational burdens. Although existing pediatric telerehabilitation systems have improved access to rehabilitation services, current approaches are largely fragmented, focusing primarily on child-centered outcomes while insufficiently addressing caregiver needs within unified decision-making frameworks.

This study proposes a digital rehabilitation platform for children with disabilities that adopts a family-centered approach by modeling the child–caregiver dyad as an integrated and dynamic system. The platform supports personalized rehabilitation planning, prioritization of intervention modules, and adaptive adjustment of rehabilitation intensity through an intelligent decision-support mechanism. The proposed system integrates multiple dimensions, including child functional status based on the International Classification of Functioning, Disability and Health (ICF), caregiver burden and self-efficacy, treatment adherence, environmental accessibility, and safety constraints. A constrained multi-criteria optimization model is used to recommend rehabilitation activities by balancing expected child improvement, caregiver well-being, adherence probability, resource limitations, and digital accessibility costs. To ensure adaptability over time, a fuzzy logic–based control module continuously updates rehabilitation plans based on

progress indicators, adherence levels, caregiver burden, and safety signals. All significant modifications require validation by healthcare professionals, ensuring clinical safety and human-in-the-loop governance.

These findings indicate that a dyadic, family-centered digital rehabilitation platform can effectively integrate child and caregiver needs into a unified adaptive framework. The proposed model provides a strong foundation for future clinical validation, usability testing, and real-world deployment, particularly in contexts where rehabilitation resources are limited and continuity of care is challenging.

Keywords: digital rehabilitation; pediatric disability; telerehabilitation; family-centered care; caregiver; explainable artificial intelligence; personalized rehabilitation; digital health.

Rehabilitation is an essential component of health care because it aims to optimize functioning and reduce disability in interaction with the person's environment. The World Health Organization (WHO) places rehabilitation within universal health coverage and emphasizes multidisciplinary, person-centered service delivery [1,2]. The global scale of need is substantial: WHO estimates that approximately 1.3 billion people experience significant disability, while UNICEF estimates that nearly 240 million children live with disabilities worldwide [3,4].

For children, rehabilitation is not limited to a single impairment. Motor function, communication, cognition, self-care, learning, participation, behavior, and environmental accessibility may interact over many years. The family therefore becomes part of the therapeutic system. In practice, mothers often coordinate appointments, perform home exercises, monitor symptoms, communicate with clinicians, and provide day-to-day assistance. Studies of mothers of children with disabilities report meaningful caregiving burden and stress, while targeted educational and digital interventions can improve self-efficacy, health behaviors, stress management, and quality-of-life-related outcomes [5–8].

Digital health provides mechanisms for extending rehabilitation beyond specialized centers through teleconsultation, mobile applications, wearable sensors, video-based movement analysis, remote coaching, electronic patient-reported outcomes, and clinical decision support. WHO's Global Strategy on Digital Health 2020–2027 explicitly promotes people-centered digital transformation and

integration of technological, organizational, and human resources rather than isolated applications [9]. In rehabilitation, recent systematic reviews indicate that home-based and technology-supported care can improve access and support continuity, although clinical evidence is heterogeneous and implementation barriers remain [10–14].

Pediatric telerehabilitation research has expanded rapidly. Ogourtsova et al. identified evidence across multiple diagnostic groups and health professions, including outcomes related to motor function, behavior, language, and parental self-efficacy [10]. Del Lucchese et al. showed that pediatric technological telerehabilitation remains highly heterogeneous and highlighted the need for dynamic, multi-domain, family-centered protocols [11]. A 2025 systematic review of early intervention delivered via telehealth found that most studies relied on caregiver coaching and that broader multidisciplinary and family outcomes remain important research gaps [12]. The 2026 Digital Pediatric Physiotherapy Framework similarly concluded that digital technologies are reshaping pediatric rehabilitation but still require coherent integration into family-centered pathways [13].

At the same time, artificial intelligence (AI) is increasingly used for rehabilitation outcome assessment, movement analysis, prediction, classification, and decision support. However, current pediatric AI applications are still predominantly analytical rather than closed-loop adaptive systems. A 2026 scoping review reported that no included pediatric rehabilitation studies implemented fully closed-loop AI in which outcome assessment directly adapted intervention delivery in real time [10]. Reviews of AI in rehabilitation also emphasize limited external validation, technology literacy barriers, reliability issues, and the need for real-world clinical evaluation [14].

This creates a clear methodological gap. Existing solutions usually optimize a child-oriented endpoint, provide caregiver education as a separate service, or focus on one diagnosis. They rarely represent the child and mother as a coupled longitudinal system in which rehabilitation intensity, caregiver capacity, adherence, accessibility, and safety are optimized together. The present study addresses this gap by proposing a Dyadic Adaptive Digital Rehabilitation Platform (DADRP) with four contributions:

1. a unified mathematical representation of child functioning, mother/caregiver status, adherence, environment, and safety;
2. a constrained multi-criteria recommendation algorithm that ranks feasible rehabilitation plans rather than autonomously prescribing treatment;
3. an explainable fuzzy adaptation mechanism that updates recommendations according to longitudinal progress and caregiver burden;
4. a human-in-the-loop governance layer in which clinicians retain control over clinically meaningful changes.

The purpose is not to replace rehabilitation professionals. Instead, the platform is designed as a longitudinal coordination and decision-support infrastructure that can make multidisciplinary rehabilitation more continuous, measurable, and family-centered.

All recommendation outputs are accompanied by a compact explanation: the highest-priority domains, the constraints that removed alternatives, and the factors that most strongly increased or decreased the plan score.

The clinician dashboard supports three actions: approve, modify, or reject. Rejected recommendations and clinician modifications are logged and can later be used for model refinement. This arrangement is consistent with WHO principles that emphasize human autonomy, transparency, safety, and accountability in AI-enabled health systems [7,9].

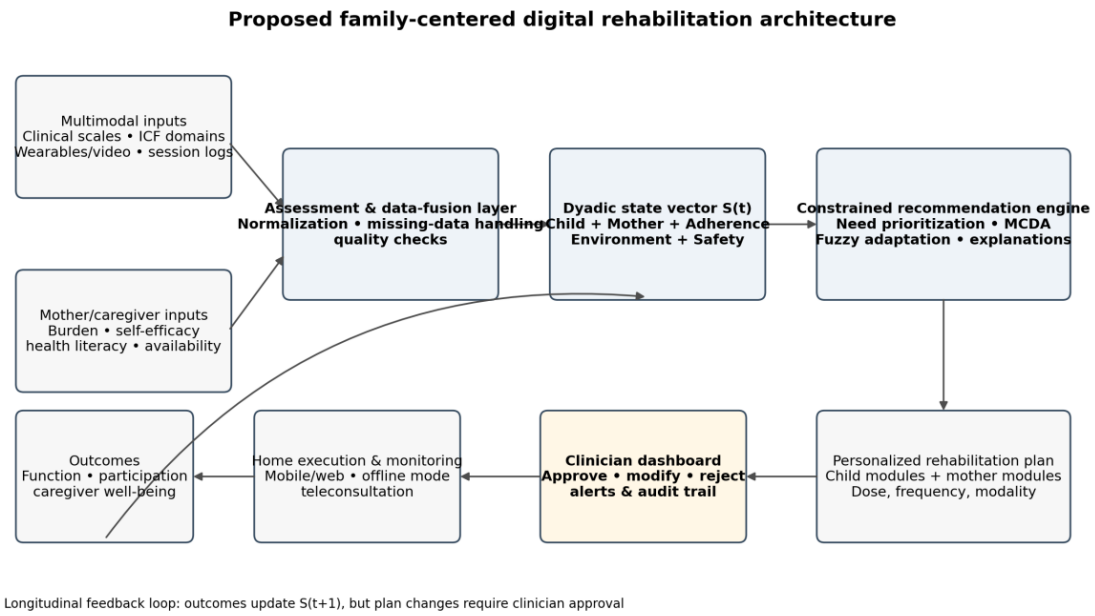


Figure 1. *Proposed family-centered digital rehabilitation architecture.*

A clinically deployable version should implement role-based access control, encryption in transit and at rest, audit logs, explicit consent/assent procedures where applicable, minimum-necessary data collection, and retention rules defined by applicable legislation and institutional governance. Data used for AI training should be separated from operational clinical records unless a specific legal and ethical basis exists. Accessibility is also a functional requirement rather than a visual preference. Interfaces should support scalable text, high-contrast modes, screen readers, captions, simple language, Uzbek/Russian/other relevant language localization, low-bandwidth operation, and asynchronous alternatives where continuous connectivity is unavailable. Digital inequity must be considered in the recommendation function so that lack of bandwidth does not automatically imply lower clinical priority.

CONCLUSION

This study presents a digital rehabilitation platform for children with disabilities based on a family-centered (child–caregiver) dyadic model. The framework integrates child functional status (ICF-based), caregiver burden and capacity, adherence, environmental factors, and safety into a unified adaptive system.

A constrained recommendation model selects optimal rehabilitation plans, while a fuzzy logic controller enables gradual adjustments under clinician

supervision. The proof-of-concept simulation suggests that the dyadic approach can maintain child rehabilitation outcomes while improving caregiver support and adherence, though results are based on synthetic data.

Overall, the main contribution is a conceptual framework showing that digital rehabilitation should jointly optimize child outcomes and caregiver capacity within a transparent, adaptive decision-support system. Further clinical validation is required before real-world application.

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ОБЗОР МЕТОДОВ МНОГОКРИТЕРИАЛЬНОЙ ОПТИМИЗАЦИИ И ЭВОЛЮЦИОННЫХ АЛГОРИТМОВ В ПРОЕКТИРОВАНИИ ЭНЕРГОЭФФЕКТИВНЫХ СИСТЕМ

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Аннотация. Настоящая работа посвящена аналитическому обзору методов многокритериального поиска и эволюционной оптимизации конструктивных параметров технических систем. Рассматривается научно-техническое противоречие между улавливающей способностью фильтрующих модулей и их энергопотреблением. Проанализированы преимущества генетического алгоритма NSGA-II в сравнении с традиционными градиентными методами применительно к задачам проектирования инженерных систем для Приаралья, опираясь на исследования отечественной и зарубежной научных школ.

Ключевые слова: многокритериальная оптимизация, алгоритм NSGA-II, фронт Парето, энергоэффективность, обзор, инженерные системы, Приаралье.

1. Введение и актуальность проблемы компромиссного поиска

При проектировании современных инженерных систем очистки и кондиционирования воздуха разработчики неизбежно сталкиваются с проблемой поиска компромисса между несколькими взаимно противоречащими критериями. В контексте климатических условий Приаралья, характеризующихся повышенной солевой запыленностью атмосферы, данная проблема обостряется. Для глубокой сепарации мелкодисперсных фракций солей требуется уменьшение размеров пор