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A Systematic Review of IoT-Enabled Assistive and Health-Monitoring Technologies for Individuals with Severe Motor Disabilities

Muhammad Sadikh N*, Harikrishnan P S**, Shehina S***, Siddiq S****, Neethu Raj R*****

* (Department of Electronics and Communication Engineering
Dr. APJ Abdul Kalam Technological University
Kerala,India.
sadikhnoushad4@gmail.com)

** (Department of Electronics and Communication Engineering
Dr. APJ Abdul Kalam Technological University
Kerala,India.
harikrishnanchandran60323@gmail.com)

*** (Department of Electronics and Communication Engineering
Dr. APJ Abdul Kalam Technological University
Kerala,India.
shehinas769@gmail.com)

**** (Department of Electronics and Communication Engineering
Dr. APJ Abdul Kalam Technological University
Kerala,India.
siddiq12@gmail.com)

***** (Head of Department
Department of Electronics and Communication Engineering
UKF College of Engineering and Technology,
Dr. APJ Abdul Kalam Technological University, Kerala, India)

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Abstract:

Rapid progress in IoT, embedded devices, robotics, and HMIs has led to newer assistive tools for individuals with movement difficulties, nerve-muscle disorders, or ongoing health issues. This review brings together five up-to-date studies focusing on body-worn monitors, smart wheelchairs, tongue-based controls, and robot helpers. Sensing methods, decision-making approaches, data transfer techniques, structure of systems, along with testing procedures are examined per study. Comparisons show wide differences - like using first-person view cameras in chairs versus mouth-mounted induction sensors for complex motion help. Key flaws emerge: few real users tested, some machines need constant input, poor compatibility between parts, little assessment over extended medical use. This review highlights new chances for integrated systems using AI that combine movement assistance, health monitoring, and flexible interface options. Findings show progress depends on teamwork, practical design, and evidence based development to shift early models into everyday use.

Keywords — Assistive Technology, IoT-Based Health Monitoring, Paralysis Rehabilitation, Tongue–Computer Interface, Smart Wheelchair Systems, Autonomous Navigation, Upper-Limb Exoskeleton

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I. INTRODUCTION

The merging of IoT, human–machine communication, and rehab-focused robots has led to advanced tools helping paralyzed people manage key everyday tasks. Since spinal damage, nerve-related diseases, or full-body paralysis usually cause major movement limitations, techbased aids filling those gaps are now critical. Today's supportive gadgets use AI alongside built-in sensors, remote links, along with self adjusting features - offering smoother, easier-to use assistance. This paper looks at five different tech-based systems, showing recent directions in assistive tech studies. One is a smart watch (HOT Watch) linked to the internet, which tracks body temp, heart activity, and blood oxygen levels through built-in medical sensors ; a WiFi-connected mouth-operated setup that controls a robot arm to pick up items or assist with distant tasks using signals from the tongue. A self-focused visual system helps guide wheelchairs without hands by tracking eye direction, head motion, while combining smart navigation methods a mouth controlled arm device tested medically on people with paralysis, enabling them to eat and drink using simple movements 4 ; also a smart wheelchair using IoT, combining simple health tracking with movement controlled by head gestures while sending alerts via GSM 5. Together, these systems highlight a move toward smart assistive tools using live health monitoring, multiple control methods, or adaptive decision making. Still, even with advances, every system faces design flaws or usability issues needing resolution prior to use in actual homes or clinics. This analysis offers a clear summary of current progress, points out major shortcomings, yet suggests paths forward for testing and implementation.

II. METHODOLOGY

The approach used in this review aimed to explore key aspects of current assistive tools and IoTbased health systems designed for people with paralysis, focusing on clarity and broad understanding. Because the subject connects multiple fields - like sensor tech, brain-machine links, robotic autonomy, circuit design, and networked devices - a step-by-step analysis method was built. Instead of relying solely on one technique, it combined several stages to gather, group, contrast, and interpret findings from the five provided studies that formed the foundation of this work. By using clear logic and open methods, the process supports verification by others while contributing meaningful insight into assistive solutions. The initial step focused on finding, gathering, testing primary sources. Five studies were picked since together they show a wide range of recent tech changes in assistive tools - such as wearables tracking body signals, controls operated by tongue movement, robotic arm supports, wheelchairs guided via visual systems, networks linking smart health devices. Prior to analysis, every paper was checked for scholarly trustworthiness, where it was published, quality of experiments, connection to aids for people with paralysis. That way, the resources used met standards for solid methods and meaningful innovation. After checking sources, the next step focused on gathering data in a structured way. Every study was examined closely - not only for goals but also for how systems were built, what hardware was used, types of sensors, algorithms applied, connectivity methods, movement controls, interface designs, and testing approaches. Important details like sensor specs, software platforms, wireless standards, levels of automation, and ways to measure results were recorded carefully - using organized formats. The approach aimed at high detail, helping comparisons across studies while capturing every significant technical point. Special focus went toward spotting novel features in each setup - as well as recognizing boundaries, weaknesses, and hidden conditions shaping their development and assessment. The third stage involved sorting data into clear groups, based on what each system was mainly designed to do. These groups formed five main types: (1) wearables using IoT to track body signals, (2) robots controlled via tongue-operated interfaces, (3) vision systems that support movement from a first-person view, (4) exoskeletons for arms guided by tongue input, and (5) wheelchairs enhanced with IoT for both tracking and navigation. Organizing them this way helped build a logical flow throughout the analysis. Instead of just listing devices, it allowed comparing similar technologies while showing how they fit within larger tech trends. As a result, the structure became easier to follow, yet offered deeper insight. The fourth stage used an analysis model based on specific technical factors. Because it focused on uniform aspects - like functionality, technology, and ease of use - it allowed comparison between the five systems. Key elements examined were: (a) types and precision of sensors, (b) how users interacted with the device, (c) processing demands and algorithm design, (d) wireless transmission methods, (e) level of independent operation and smart control features, (f) comfort and physical fit, (g) target user group and medical applicability, (h) ability to connect with other support tools, and (i) known drawbacks or implementation issues.

TABLE I

COMPARISON OF ASSISTIVE SYSTEMS

COMPARISON ASPI	IOT WEARABLE HEALTH MONITORING [1]	TONGUE-CONTROLLED ROBOTIC MANIPULATOR [2]	EGOCENTRIC CV WHEELCHAIR NAVIGATION [3]	TONGUE-CONTROLLED UPPER-LIMB EXOSKELETON [4]	IOT-BASED SMART WHEELCHAIR [5]
Primary Focus	Continuous physiological monitoring	Object manipulation using tongue interface	Autonomous/semi-autonomous wheelchair navigation	Upper-limb assistance for daily activities	Basic wheelchair mobility with monitoring
Assistive Domain Coverage	Health monitoring only	Manipulation only	Mobility only	Upper-limb movement only	Mobility with limited monitoring
Mobility Support	Not addressed	Not addressed	Core function	Not addressed	Basic control only
Object Manipulation Capability	Not supported	Core function	Not supported	Limited to limb motion	Not supported
Computer / Digital Access	Not supported	Not supported	Not supported	Not supported	Not supported
Home Automation	Not supported	Not supported	Not supported	Not supported	Very limited (alerts only)
Human–Machine Interface Type	Mobile application interface	Tongue- based continuous control	Head, gaze, and voice- based control	Tongue-based continuous control	Head gestures and physical switches
Unified Control Interface	No	No (task- specific)	No (navigation-specific)	No (exoskeleton-specific)	No
Multi-Device Control Capability	None	Single device only	Single device only	Single device only	Single device only
System Integration Level	Low (standalone wearable)	Moderate (robot and interface integration)	High (navigation stack only)	Moderate (exoskeleton and interface)	Low to moderate
Cost Consideration	Moderate	High (commercial robotic hardware)	High (vision sensors and computation)	High	Low
Customization and Scalability	Limited	Limited by hardware cost	Limited by system complexity	Limited to exoskeleton design	Limited functionality
Clinical Validation	Limited validation	Evaluated on non-disabled users	Limited clinical exposure	Clinically validated	Minimal
Control Resolution	Not applicable	High- resolution control	Moderate resolution	High-resolution control	Low resolution
Dependency on Complex Hardware	Low	High	Very high	High	Low
Coverage of Daily Living Needs	Partial	Partial	Partial	Partial	Partial
Key Limitation	Passive monitoring without active assistance	Single- purpose and expensive	Mobility-only with high complexity	Functionally narrow	Low precision and limited scope
Major Missing Aspect	Active physical assistance	Integrated multi-domain control	Manipulation and digital access	Mobility and environment control	Multi-use precision

III. RESEARCH GAP

The analysis of the five reference works reveals a substantial research gap in the development of assistive technologies for individuals with severe motor impairments. Although each study makes a meaningful contribution within its specific domain—such as health monitoring [1], robotic manipulation [2], autonomous wheelchair navigation [3], upper-limb assistance [4], and basic smart wheelchair functionality [5]—the literature remains dominated by single-purpose, function-specific solutions. There is a notable absence of systems that address multiple assistive needs simultaneously within a unified framework. A key gap lies in the lack of integrated assistive architectures. Current systems operate as isolated modules, requiring users to rely on separate devices and interaction methods for different daily activities. This fragmentation increases cognitive and operational burden and reduces overall usability for individuals with severe tetraplegia. None of the reviewed studies proposes a comprehensive platform capable of coordinating mobility, manipulation, digital interaction, and environmental control through a single interaction paradigm. Another important gap is the limited exploration of universal, high-resolution human–machine interfaces. While tongue-based control has been demonstrated as effective in robotic manipulation [2] and upper-limb assistance [4], its application remains confined to narrow tasks. Existing research does not extend this interface to multi domain control, despite its potential to serve as a centralized input modality for diverse assistive functions. Cost and scalability also remain under-addressed. Several advanced systems depend on commercial robotic hardware [2], complex exoskeletons [4], or computationally intensive vision systems [3], which restrict affordability and large-scale deployment. The literature lacks sufficient emphasis on cost-effective, customizable, and easily reproducible assistive solutions that can be adapted to different environments and user needs. Additionally, the reviewed works show minimal integration with digital and smart environments, such as full computer access and home automation. While basic alert mechanisms are present in some systems [5], comprehensive interaction with digital platforms—essential for communication, education, and independent living—is largely absent. These gaps collectively indicate the need for more holistic, user-centered assistive systems that extend beyond isolated functional support.

IV. FUTURE SCOPE

Future research in assistive technology should focus on developing multi-functional assistive systems that integrate several domains of independence within a single, cohesive framework. Rather than designing task-specific devices, upcoming systems should aim to support mobility, object manipulation, digital interaction, and environmental control simultaneously, thereby reducing system fragmentation and improving usability for individuals with severe motor impairments. There is considerable scope for advancing unified human–machine interfaces, particularly by extending high-bandwidth modalities such as tongue-based interaction to control multiple assistive devices. Expanding these interfaces beyond isolated applications could enable seamless transitions between tasks without the need for additional controllers or interfaces, significantly lowering cognitive load. Future systems should also prioritize affordability and scalability, emphasizing low-cost embedded platforms, modular hardware designs, and customizable components. This approach would make advanced assistive technologies more accessible and adaptable across different socioeconomic and geographic contexts. Another important direction involves deeper integration with digital ecosystems, including computers, communication platforms, and smart home technologies. Enabling assistive systems to function as comprehensive human–computer interfaces and smart-environment controllers would greatly enhance independence in communication, work, and daily living. Finally, future work should explore adaptive and extensible system architectures that allow assistive technologies to evolve with user needs. Incorporating flexible software frameworks and modular expansion capabilities would support long-term use, upgrades, and personalization without requiring complete system redesigns.

V. CONCLUSION

The look at five chosen studies shows tech help for people with serious movement issues has come a long way. These papers show real fixes in different areas - like tracking body signals nonstop, using tongue moves to control robots, wheelchairs that drive themselves partway, robot arms aiding limbs, or internet-connected gear boosting mobility. Every project proves high-end sensors, brain-machine links, radio data transfer, and smart decision systems can actually work where they're meant to. Even with progress, one big problem shows up in every study: help features don't work together. Systems focus on just one thing - like moving around, grabbing objects, or tracking health - but ignore how real life needs many things at once. Because of this, people end up using several separate gadgets. Each gadget runs on its own gear, controls, and setup method. Jumping between them makes it harder to keep track, more confusing to use, and leads to relying more on others - which weakens how useful these tools actually are. The findings show advanced brain-machine links especially those using tongue commands - work well but only handle specific jobs. Still, they haven't evolved into general tools for broader assistive uses. In a similar way, camera-guided movement tech allows smart navigation yet focuses just on getting around, needing heavy gear and processing power, which blocks wide adoption. On the flip side, body-worn health trackers help doctors keep watch but stay inactive when it comes to engaging with surroundings or devices. A key point that stands out, Assistive tools don't connect well with digital or smart setups. Getting into computers, messaging apps, or automated homes matters a lot for school, work, and staying involved socially yet hardly any studies talk about it. That gap shows how tech advances often miss what users really need day to day. Staying independent means smoothly moving between real-world settings and online ones - but right now, those pieces aren't fitting together. Few people talk about costs or how well things work at scale. Some setups use pricy robot parts, custom wearable frames, or advanced sensors - making them tough to use where money's tight. Since cheap, flexible, and adjustable models aren't a priority, most folks still can't get their hands on these tools.

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