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A Comprehensive Review on Raspberry Pi: A New Tool to Support Disabled

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***Abstract*— The Raspberry Pi (RPi), an affordable computer about the size of a credit card, has changed the way computers are used because they are so flexible and can be used for so many things. This paper gives a comprehensive analysis of the Raspberry Pi, looking at how it has changed from its first release to the newest models and looking at its main hardware parts and different kinds. The study talks about the pros and cons of the Raspberry Pi. The pros include low power use, flexibility, and community support. The cons include limited processing power and storage. A lot of attention is paid to the creative ways that Raspberry Pi can be used in technologies that help people with disabilities. The Raspberry Pi is a powerful tool for making smart assistive devices like voice-controlled systems, glasses that identify obstacles, and real-time navigation aids. It does this by combining sensors, cameras, and AI-based models. The purpose of this paper is to show how Raspberry Pi can be used to give disabled people more power, encourage them to live on their own, and promote acceptance through technology.**

***Index Terms*— Raspberry Pi, Embedded Systems, IoT, Low-cost Computing, Edge Devices, Robotics.**

I. INTRODUCTION

At a time when technology that works for everyone is so crucial, the Raspberry Pi has changed the game by connecting education, research, and real-world innovation. It is cheap, compact, and has a lot of methods to link to other devices, which is why many like it for IoT and embedded devices. The fundamental goal was to make it easier for everyone to use computers. There has been a lot of research on systems that use Raspberry Pi, notably those that help individuals with disabilities. But most of the research is all over the place, looking at different use cases without a clear mechanism to compare hardware setups, software techniques, and real-world performance
This study takes the field forward by developing a unified taxonomy for Raspberry Pi assistive apps that sorts them by type of disability, hardware setup, AI integration, mode of use, and price range. Previous assessments just looked at programmes, but our analysis looks at several solutions in depth, taking into account their features, claimed performance indicators, and ability to grow. We also see five major problems with the research: it isn't standardised, it doesn't speed up AI enough, it doesn't have enough user-centred trials, and it has terrible scaling frameworks. Next, we show you how to fill up these gaps step by step.

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This review is new because it does two things: (1) it collects and organises more than 20 Raspberry Pi-based assistive solutions into a design reference that can be used again, and (2) it explains useful design principles that can help engineers, educators, and policymakers make assistive technologies that are cheap, easy to use, and easy to scale [1].

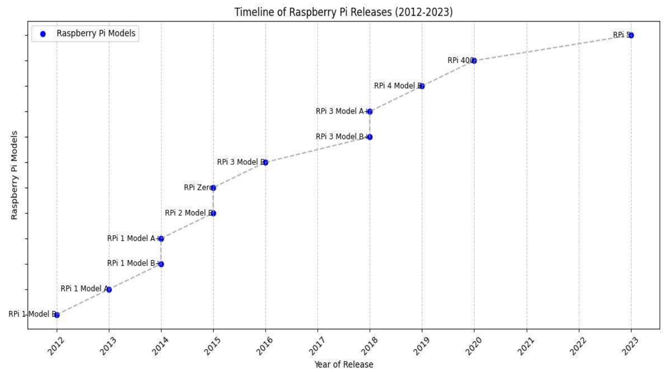

Figure 1. Timeline of Rpi

Different Raspberry Pi models are being released to meet the needs of various users as shown in Fig. 1 These models consist of Zero, ZeroW, ZeroWH, A/A+, 2, 3, 3B/3B +, 4, 4B, 5 and 400 as shown in Fig. 2 Since its initial release, the Raspberry Pi has undergone remarkable advancements in terms of performance, functionality, and adaptability.

Each successive generation has introduced notable upgrades, reflecting the platform's evolution to meet the growing demands of various computing applications. The following overview highlights the key features and improvements introduced with each major model, demonstrating how the Raspberry Pi has matured into a versatile tool for both educational and industrial use. Fig. 3 illustrates the fundamental elements of a standard Raspberry Pi board. This contain the General-purpose Input/Output (GPIO) pins, which are essential for interfacing with a diverse array of scientific instruments and sensors.

Additional components include the processor, memory, ethernet port, USB port, power supply, and general-purpose input/output interfaces. The exact arrangement and components of model may differ based on the specific model of the Raspberry Pi.

- USB ports — these interfaces facilitate the connection of input devices such as a mouse and keyboard. Additionally, one may connect various other peripherals, including a USB flash drive.
- SD card slot — this component serves as the insertion point for the SD card. It is within this slot that the operating system software and user data are maintained.
- Ethernet port — this port is employed to establish a wired connection between the Raspberry Pi and a local network. As well, the Raspberry Pi is able to connecting a network by wireless local area network (WLAN) capabilities.
- Audio jack — this interface enables the connection of audio output devices such as headphones or external speakers.
- HDMI port — this is the interface utilized for connecting the monitor or projector that displays the output generated by the Raspberry Pi. In cases if the monitor has built-in speakers, audio playback may also be done with them.
- Micro USB power connector — this is the point at which an external power supply should be connected. It is advisable to execute this connection last, after all other components have been established.
- GPIO ports — these ports provide the capability to interface with electronic components, such as light-emitting diodes (LEDs) and push buttons, facilitating interaction with the Raspberry Pi.

With its 40 general-purpose input/output (GPIO) digital signal ports, the Raspberry Pi enables embedded projects to employ a variety of digital sensors. In addition, unlike Arduino, which only supports C and C++, it supports a large number of programming languages, including C, C++, Java, Ruby, Python, and C#.

Numerous Integrated Development Environments (IDEs) are available for Raspberry Pi coding applications. The Python Integrated Development and Learning Environment (IDLE) [2], BlueJ [3], Lazarus [4], Geany [5], Thonny [6], Code::Blocks [7], and Adafruit WebIDE [8] are a few of the most well-known and extensively utilized IDEs.

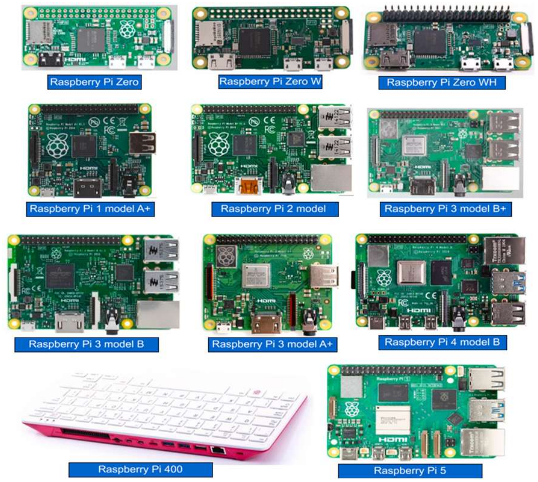

Figure 2. Different Raspberry Pi board models.

A. Advantages using Raspberry pi

The Raspberry Pi is a low-cost, flexible computing platform that is becoming more famous for use in many areas, especially in agriculture, IoT, and education. In addition to its many benefits, it also has some issues that users should be aware of. Here are some of the main advantages and drawbacks of the Raspberry Pi.

- Flexibility and Customization: It can be easily programmed and customized for various applications, including IoT and sensor networks [9], [10].
- Low Power Consumption: Its energy efficiency makes it suitable for long-term deployments in remote or mobile applications [10].
- Educational Tool: It serves as an excellent platform for learning programming and computer science concepts, appealing to a wide range of users.

B. Drawbacks using Raspberry pi

- Limited Processing Power: Compared to traditional PCs, the Raspberry Pi has lower processing capabilities, which may hinder performance in resource-intensive applications [9].
- Peripheral Dependency: Users often need additional components (e.g., sensors, displays) to fully utilize its capabilities, which can increase overall costs [10].
- Software Compatibility: Some software applications may not be compatible with the Raspberry Pi's operating systems, limiting its usability in certain contexts [9].

C. Objective of this Review

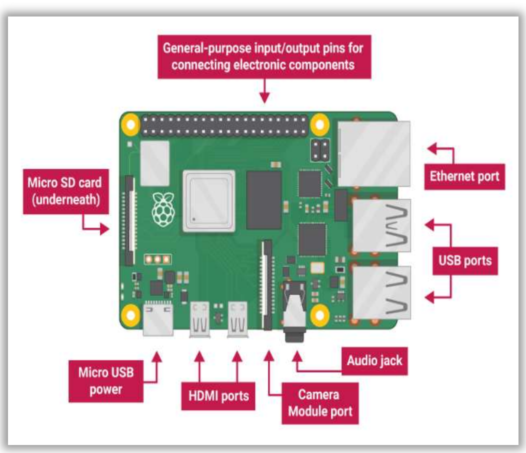

Figure 3. Components of Raspberry pi

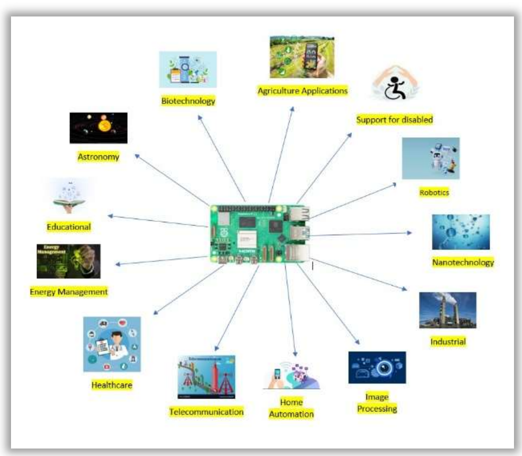

Figure. 4 Areas of study where the Raspberry Pi used

This review's goals are to: (i) collect and compile the body of existing literature on Raspberry Pi applications; (ii) investigate the potential and importance of the Raspberry Pi in prototyping; (iii) evaluate the advantages and drawbacks of using the Raspberry Pi for prototyping; (v) address research issues and challenges related to the development of prototyping solutions in various fields; (iv) give a summary of the commonly used sensors, hardware, and software that are used with the Raspberry Pi during prototyping; (v) identify and discuss potential gaps and uncharted areas for future research and development to support people with disabilities.

II. Applications of Raspberry Pi

Raspberry Pi's potential applications cover a wide range of fields, including engineering, computer science, physics and astronomy, biochemistry, genetics, molecule biology, material science, chemistry, and environmental science.
Prospective applications of Raspberry Pi can be found in a various of fields as shown in Table 1.

TABLE I. RASPBERRY PI APPLICATIONS

Fields	References
Intelligent Transport systems	[13,14]
plant science	[15,16]
mechanical engineering	[17]
telecommunication	[18,19]
home automation	[20,21]
Nanotechnology	[22-25]
chemical applications	[26-28]
Astronomy	[29,30]
environmental science	[31]
Physics	[32,33]
surveillance system	[34,35]
intelligent vehicle parking solutions	[36]
control of household appliances	[37,38]

Some of the research areas where Raspberry Pi is frequently used for prototyping are shown in Fig. 4.

A. Support for disabled

The Raspberry Pi is a key component in the development of assistive technologies for individuals with disabilities. Because of its open-source nature, low cost, and widespread availability, developers are utilizing it to create low-cost aids that address a range of disabilities, including mental, locomotor, speech, hearing, and vision impairments.
These systems utilize sensor-based and computer vision technologies to act as assistive devices, making daily tasks of the disabled more manageable. Unlike traditional solutions, Raspberry Pi based solutions offer cost-effective alternatives to improve the quality of life of people with disabilities, facilitating their participation in society.
Raspberry Pi technology has emerged as a versatile tool for developing assistive devices that support individuals with disabilities. Various innovative systems leverage its capabilities to enhance communication, navigation, and independence for users with visual, auditory, and mobility impairments. The following sections outline key applications of Raspberry Pi in assistive technology.
K. Rambabu et al. [39] showed a sample of smart glasses that can help people who are blind or have low vision. The glasses use Raspberry Pi 4 B as their main processor. Face recognition and distance tracking technologies are built into this system, which helps users find their way around and identify people. The prototype has a Raspberry Pi camera, a sonar sensor for measuring distance, and a special pair of glasses. Together, these parts make up a complete support system that helps people who are blind or have low vision see better and find their way around better.
A study by Anusha B. Ballary et al. [40] shows a Raspberry Pi-based aid device that can help disabled people, especially those who are blind, deaf, or dumb. It helps people communicate by turning sign language into text and audio, so people who can't speak can send notes both visually and audibly. The system uses a camera to recognize gestures and a microphone to turn words into text. Messages are sent through an LCD screen and a speaker, which helps disabled people be more independent and confident in their daily lives. Mudasar Basha et al. [41] used Raspberry Pi as a microcontroller to create a device to help people who are blind or have low vision. Character recognition technology is used to turn text into audio, which lets users find goods, read labels,

and get written information. There are four major steps that make up how the system works: identifying objects, localizing text, extracting text, and turning text into speech. With the help of a camera and optical character recognition, it turns visible writing into audible speech, which is very helpful for disabled people. Sudha G. et al. [42] show how Raspberry Pi can be used to help visually impaired people by turning writing in their environment into speech. It uses the Python OpenCV library to process images and ultrasonic sensors to find barriers and warn users of possible dangers. Heart rate trackers also keep an eye on the user's health, and GPS technology lets caretakers know where they are in case of an emergency. This all-around method is meant to help visually impaired people live more independently and safely in their daily lives. Mary Posonia [43] talks about a Raspberry Pi-based blind navigation support device that helps people who are blind find their way around. The system uses OpenCV, a Noir camera, TensorFlow (YOLO) to find things and ultrasonic sensors to let you know about found objects in real time through audio cues. Users' freedom and safety are increased by this technology, which makes their quality of life much better by letting them move around freely and safely in different settings. M. Ganesan et al. [44] shows off a Raspberry Pi-based smart walking stick that is meant to help people who have trouble walking or seeing. This intelligent walking stick has a camera, a voice recorder, and a speaker built in. It lets users see hurdles and decide how to get around them. By giving this help, the device hopes to boost users' freedom and morale, making it easier for them to go about their daily lives. Sushil Kumar Sahoo et al. [45] talk about a Low-Cost Voice-Controlled Wheelchair that was made on the Raspberry Pi to help people who have physical challenges. This new assistive technology lets people use voice commands to control their wheelchairs, which gives them more freedom and movement. The system has a microphone and motor controllers. It uses Python code and open-source voice recognition technology to understand commands correctly. It aims to improve the quality of life for disabled people by giving them an affordable option that lets them get around on their own.

Hidayat et al. [46] made an electronic test device for disabled students that uses the Raspberry Pi as a data processor and has buttons for navigation and braille. also helped disabled students by giving them an electronic testing device that made tests easier for people who are blind or have low vision. Anandan et al. [47] showed a system for finding objects and navigating that uses the Raspberry Pi and turns visual information into sound. An idea from Park et al. [48] for a Raspberry Pi-based object recognition system that makes the roads safer for blind people by recognising pedestrian signs and obstacles. [49] used the Raspberry Pi and the Google object detection API to create an obstacle recognition system that helps blind people get around barriers. Khan et al. [50] made a cheap visual aid system, and ABirami et al. [51] used deep learning in a smart glass to help blind people see objects. Vasanth et al. [52] used the Raspberry Pi and the Google Speech API to help people who are blind or deaf. Lu et al. [53], who were writing for wheelchair users, made an IoT system to keep an eye on smart scooters. Chatterjee et al. [54] used Raspberry Pi to make a mixed-control wheelchair (MCW) that is easier for people with disabilities to use.

The preceding review focuses on the many beneficial applications built with Raspberry Pi. However, the outcomes are not always consistent across different investigations. To give everyone a clear picture, we suggest a taxonomy that organises Raspberry Pi-based assistive apps into groups depending on the type of handicap, the way people interact with them, the amount of AI integration, and their ability to be scaled up or down. This taxonomy, displayed in Table 4, brings together the research that was looked at and allows future research and design initiatives a means to be arranged.

III. DISCUSSION

This work creates a complete taxonomy for Raspberry Pi-based assistive devices. This will help future researchers identify, compare, and design solutions in a more organized way. We looked at more than 20 implementations for different kinds of disability and found certain design patterns. For instance, Pi 4B is the most popular instrument for helping people see, audio feedback is utilized for helping people find their way, and haptic modalities aren't used enough, even though they could be useful in calm settings.

The taxonomy also shows where additional research needs to be done. First, most of the solutions are prototypes that aren't standardized, which makes it hard for them to work together and be used on a big scale. Second, AI acceleration is still uncommon. Fewer than 15% of the solutions we looked at used technology like Coral Edge TPU to process data in real time. Third, there isn't much validation that focuses on the user; fewer than 10% of research reported trials with real target users.

Our proposal says:

- Adding edge AI accelerators to speed up things in the real world.

- Creating open-source modular frameworks that make it simple to share code and get devices to work together.
- Standardized approaches to check how easy it is to use assistive devices to make sure they work for people with disabilities.
- We're thinking about using systems that give input through sound, touch, and sight to make things easier to get to.
- Research that looks at how to get the most for your money by striking the right balance between price and extra features.

IV. CONCLUSIONS

This research gives us the first complete list of assistive technologies that work with Raspberry Pi. You may then organize and compare them in a systematic way depending on the type of impairment, the style of interaction, the level of AI integration, and the possibilities for scaling. We look at over 20 solutions and talk about trends, patterns in performance, and areas of research that need more work so that future research can have the most effect on society. We are not just putting together previous work; we are also turning broken research into a design reference framework. This gives engineers and scientists the tools they need to quickly locate the proper hardware and software setups, stop repeating the same tests, and come up with fresh ideas. Our suggested roadmap is based on making everything the same, speeding up AI, and testing with a lot of different users. Following it will help Raspberry Pi-based assistive systems grow from being separate prototypes to solutions that can be used by many people with disabilities and change their lives. Standards, AI acceleration, and user-centred validation should be the main areas of future study in order to turn Raspberry Pi-based assistive prototypes into deployed real-world solutions.

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