A Study on the Development of Barrier-Free Kiosk Systems Using Height-Based UI Adaptation

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Abstract

A kiosk is an interactive device that provides users with information or services through a touchscreen interface. Many kiosks fail to accommodate users with physical limitations, such as wheelchair users, elderly individuals, and children, due to fixed interface layouts and limited adaptability. Physical impairments are strongly associated with the need for wheelchair-accessible kiosks and adaptable kiosk height control functions to ensure usability. To address this issue, a barrier-free kiosk system was developed that dynamically adjusts the user interface based on the detected height of each user. The system integrates a Raspberry Pi 5, a camera module, and the YOLOv11 object detection model to estimate height in real time. A short-user priority rule is applied in multiple user scenarios to enhance accessibility.

Keywords: accessibility, barrier-free kiosk, Raspberry Pi, user interface, YOLO.

Ⅰ. Introduction

Self-service kiosks are becoming more common in public spaces, offering convenience and efficiency. However, many of these systems fail to meet accessibility standards, particularly for individuals with mobility impairments. Similar challenges are faced by the elderly and children, who may struggle to use kiosks due to physical limitations or mismatched interface design. Although accessibility guidelines and legislation exist, research shows that current kiosk implementations often overlook critical physical access considerations, such as reach range, screen height, and touch target placement [1].

Park et al. [1] analyzed domestic and international regulations and found that while accessibility standards are established, their real-world application often fails to translate into practical usability for diverse user groups. For wheelchair users, interface elements may be positioned too high to reach comfortably. Elderly users may experience difficulty due to reduced vision or slower response time. Children, on the other hand, are often excluded from kiosk interaction entirely due to their small proportions and limited reach.

These issues are not only technical problems but also reflect a common design assumption that all users are standing adults with average physical characteristics. As a result, many kiosk systems are difficult to use for individuals with diverse physical capabilities and accessibility needs. To improve accessibility, kiosk designs need to be more flexible and capable of adjusting to users with different heights and abilities.

This study aims to develop a barrier-free kiosk system to dynamically modify its user interface layout according to the user's detected height. With the goal to enhance accessibility for individuals who encounter difficulties when using conventional kiosks, such as wheelchair users, elderly individuals, and children [1]. The system architecture is built on a Raspberry Pi 5, which functions as the primary processing platform for both user detection and interface adjustment. This height-based UI adaptation seeks to enhance accessibility and usability for a broader range of users, especially those often underserved by conventional kiosk design.

Ⅱ. Method

The proposed height-adaptive kiosk system is implemented using a Raspberry Pi 5 as the central processing platform for user detection and interface adjustment [3]. A camera module is installed above the kiosk display to continuously capture video input of users standing in front of the kiosk. The captured frames are processed in real time using YOLOv11, a deep learning-based object detection algorithm optimized for accuracy and efficiency in live detection scenarios [2].

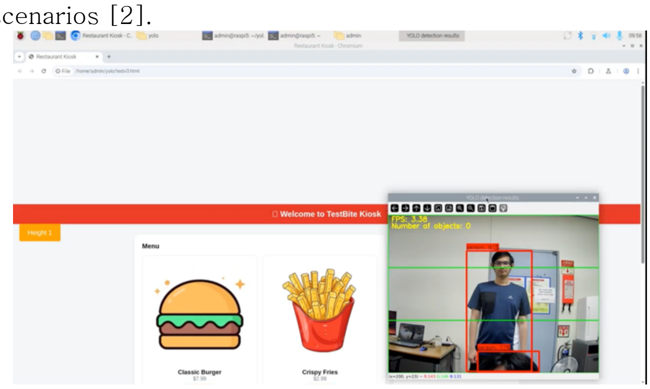

Figure 1. User Interface

The detection model identifies individuals in the frame and generates bounding boxes. The vertical dimension of each bounding box is utilized to estimate the user's physical height in relation to the kiosk display. This information is then used to modify the user interface layout, ensuring that interactive elements are positioned within convenient reach. In scenarios where multiple users are present, the system implements a short-user priority rule by selecting the lowest bounding box in the frame, based on the assumption that this user is more likely to encounter accessibility barriers.

This methodology is informed by prior research in adaptive and intelligent user interface design that focused on enhancing accessibility in public self-service environments [4] and aligns with recent studies emphasizing the significance of visual and interaction design in fast-service kiosks [5].

The front-end interface is developed using HTML, while OpenCV is used for processing the video stream and rendering bounding boxes on the display. The detection system functions at an average of 3.38 frames per second, providing responsive adjustments during live interactions. Detection outputs and system status messages are recorded through a terminal interface to support system monitoring and debugging.

A working prototype was tested in a monitored environment to verify system performance. The interface correctly responded to user height in both single-user and multi-user scenarios. The short-user priority rule consistently identified the lowest bounding box, allowing accessible interaction for individuals in wheelchairs or of shorter heights.

Ⅲ. Conclusion

This study presented the development of a barrier-free kiosk system that adapts the user interface based on the detected height of each user. The system was developed on a Raspberry Pi 5 and utilizes the YOLOv11 object detection model to dynamically adjust interface elements and enhance accessibility for wheelchair users, elderly individuals, and children. A short user priority rule was applied to address diverse physical needs, and the system implementation achieved an average speed of 3.38 frames per second, demonstrating real-time responsiveness that is suitable for public use.

Future improvements include more seamless adjustments, automatic detection based on touch, and group detection.

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