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Digital Chess Clock for Visually Impaired Players

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Abstract:
Traditional and digital chess clocks pose significant challenges for visually impaired chess players during tournaments. This study proposes a groundbreaking solution: a digital chess clock featuring audio functionality that audibly indicates remaining time, thus addressing the unique needs of blind players. Powered by an Arduino Uno processor and equipped with an LCD keypad shield for intuitive time management, this innovative clock empowers players to precisely set and monitor game time in hours, minutes, and seconds. Additionally, it incorporates mini pushbuttons for seamless transition between players and triggers for audio output through integrated 0.5 W stereo speakers. By providing auditory cues, this digital clock becomes an indispensable tool for visually impaired players, enhancing their independence and confidence on the chessboard. In summary, this project aims to revolutionize the tournament experience for blind chess enthusiasts by ensuring equitable access to precise time management tools, ultimately leveling the playing field, and fostering a more inclusive chess community.

Keywords: Digital chess clock; Chess; Visually impaired players

1. INTRODUCTION

According to the World Health Organization's (WHO) study on vision, there are at least 2.2 billion visually impaired persons in the world (1). In about half of these cases, vision impairment could have been prevented or remained unaddressed. Visual impairment and blindness are mostly caused by cataracts and untreated refractive errors on a global scale. Vision impairment can affect individuals of all ages, with a higher prevalence among those aged 50 and older. Regarding regional differences, the rate of distant vision impairment in low- and middle-income countries is almost four times that of high-income regions.

Chess is a well-known and renowned strategy game that involves ability, strategy, and concentration (2). However, visually challenged players frequently encounter difficulties using standard chess clocks, making it difficult for them to play at the same level as sighted players. Due to its reliance on visual clues such as the position of the minute and second hands or the digital numbers to indicate the amount of time remaining on the clock, visually impaired players have difficulty utilizing traditional or digital chess clocks (3). This challenge in keeping track of time can hinder the performance of visually challenged players in the game. In addition, many traditional chess clocks are not designed to be accessible to visually impaired players and may lack features such as audible cues or tactile buttons that would make it easier for visually impaired players to use the clock (4, 5). This significantly hinders the ability of visually impaired players to compete at the same level as sighted players in the game of chess.

The dearth of user-friendly and accessible chess clocks for visually challenged players is a problem that must be addressed. Chess is a valuable instrument for improving cognitive and strategic abilities, and visually challenged players should have the opportunity to enjoy it. Creating a digital chess clock developed exclusively for visually challenged players would go a long way toward resolving this issue and levelling the playing field for all players. The proposed study introduces a digital chess clock specifically designed for visually impaired players, featuring audio output indicating the remaining time with the push of a button.

2. MATERIALS & METHODS

This study implemented the use of a 0.5W speaker for voice output, Arduino Uno as the processing board for the entire system, an LCD keypad shield to display and control time settings, two push buttons to switch timing, and two push buttons to trigger the output of time at specific moments.

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2.1 Interview with Blind Chess Player

Prior to implementing the study, a comprehensive understanding of the actual challenges faced by visually impaired players was gained through participation in the 3rd Malaysia Lions Club International Chess Championship for Disabled. Additionally, interviews were conducted with five visually impaired players to gather firsthand data, ensuring the relevance and effectiveness of the study. From these interviews, it became apparent that a chess clock capable of audibly announcing the time holds significant importance, greatly facilitating time management during chess games. Currently, time is typically managed with the assistance of a helper, arbiter, or occasionally by the players themselves. However, the introduction of a talking chess clock has the potential to significantly enhance the timekeeping experience. While some players have already experienced such a clock, with one noting a slower response time, others are yet to try it. In terms of suggestions for improvement or modification, it would be beneficial if a single click could provide access to the remaining times of both players, further streamlining the process. Figure 1 illustrates the interaction with visually impaired players during data collection, while Table 1 provides details of the visually impaired players interviewed.

Figure 1. Interacting and interviewing visually impaired chess players at 3rd Malaysia Lions Club International Chess Championship for Disabled event.

Table 1. Visually impaired chess players details.

Chess Players	Age
Player 1	30
Player 2	31
Player 3	26
Player 4	26
Player 5	30

2.2 Development of Digital Chess Clock System

2.2.1 Menu Setup for Chess Clock

Firstly, the options menu was designed and coded in the Arduino IDE. The implemented menu includes features for setting the time in hours, minutes, and seconds, along with additional functionality for setting the increment value. To code the setup option, the keypad buttons were defined to interface with the LCD keypad shield. Several necessary variables for the keypad and menu were introduced, followed by the variable for the increment value.

To read the keypad buttons, the '**adckey**' variable was configured to correspond to specific values. For example, a value less than 380 indicates the activation of the down button. When a button is pressed, it returns a value to the A_0 pin based on the internal resistive splitting circuit, which identifies the type of key pressed. Subsequently, coding was implemented to dictate the response of the setup menu.

After coding the operation of the menu option, the display section was developed. For displaying the menu, the pins were initialized as detailed in Supplementary Data A. Both white and black values were programmed under the functions '**printTimerWhite**' and '**printTimerBlack**', which include hours, minutes, and seconds. Next, the coding for the first line of the menu setup was executed, followed by the display of the increment. Finally, labels were added using the functions '**lcd.print**' and '**lcd.setCursor**'.

2.2.2 Time Function Code

According to Supplementary Data B, the provided code implements timer functionality. Initially, variables for the seconds count were initialized, followed by variables for the white timer and black timer. The seconds were defined and run in Millis. The maximum values were set to six hours, 59 minutes, and 59 seconds. The provided code consists of three sections, each containing "if" statements with specific conditions.

In the first section, it checks if the second timer (secWhite) is at -1 and the minutes timer (minWhite) is greater than or equal to 0. If true, it updates the '**setSecWhite**' variable and decrements '**minWhite**'. The second section checks if '**secWhite'** and '**minWhite'** are both -1 and if '**hrWhite**' is greater than 0. If true, it updates '**setSecWhite'**, '**minWhite'**, and decrements '**hrWhite'**. The third section checks if all three timers have reached 0, entering an infinite loop. Within this loop, it manipulates the LCD display on a keypad shield, clearing a section, displaying "**WINNER**", and turning off the timer. This loop repeats indefinitely. The loop function calculates the elapsed time since a previous count of seconds and determines the accurate count for the white timer based on the elapsed time.

2.2.3 Time Changing Input Code

Supplementary Data C offers the code for time-changing inputs or pushbuttons. Initially, the mini pushbuttons were initialized to their respective pins in the early part of the code. Subsequently, both pushbuttons were configured as inputs under the setup function using the '**pinMode**' variable. Next, in the loop function, when the initialized '**buttonW**' is low, the difference between SEC and the previous seconds count is calculated, initiating the white timer. When a button is high or pressed, it exits the loop or provides no response. The same concept was applied to the black side of the study.

2.2.4 Voice Output Trigger

Supplementary Data C outlines the initialization of '**WhiteB**' and '**BlackB**' to their respective pins. In the setup function, they were configured as input buttons for voice output. '**WhiteB**' and '**BlackB**' were set to low using the '**digitalRead**' function. This setup ensures that when the push button is pressed, the speaker will produce output through the '**say_time**' function.

2.2.5 Speech Library

The speech library utilized in this code is the ***talkie.h*** library, which is readily available for Arduino. This library incorporates various headers, including the official talkie library header. The talkie library comprises several files or libraries of words, such as ***Vocab_US_Large.h***, ***Vocab_Special.h***, and notably ***Vocab_US_Clock.h***, which contains essential words related to timekeeping. As illustrated in Supplementary Data D, within the '**say_time**' function, specific words to be spoken or voiced during the trigger are configured for the white side using if statements. A similar approach is employed for the black side in the code.

2.2.6 Increment Feature

One additional feature incorporated into this study was the implementation of time incrementation. This feature is optional, as it may not be utilized in every chess match. The increment functionality operates by adding a specified value, such as three minutes, to a player's timer once they complete their move.

In the code, the '**setInc**' variable is initialized earlier and subsequently declared within both the '**incWhite**' and '**incBlack**' functions, as demonstrated in Supplementary Data E. These functions, **'incWhite'** and '**incBlack**', are responsible for implementing the increment for the white and black timers, respectively. They are declared again within the loop function, as shown in Supplementary Data C, to ensure their activation if they are utilized.

2.2.7 Hardware Implementation

For this study, the components used included the Arduino Uno as the processor board, a 0.5 W speaker for output, an LCD keypad shield, two mini pushbuttons, two pushbuttons, and a TDA7266 module serving as the audio amplifier for the speaker. Figure 2 illustrates the schematic diagram of the study.From Figure 2, it can be observed that the LCD keypad shield was connected to pins 4, 5, 6, 7, 8, 9, and 10 for the LCD display, while the keys on the shield were connected to the analog pin A0. Two mini pushbuttons responsible for time switching were connected to pins 12 and 13, whereas the two pushbuttons acting as the voice output triggers were connected to pins 2 and 3. Each pushbutton was connected with a 1 kΩ resistor. Additionally, for the audio output part, the TDA7266 audio amplifier module was connected to pin 11 as the input, with the 0.5W speaker connected to the output of the amplifier module. All components were powered through the 5V pin and connected to the ground pin. The LCD keypad shield, not visible in the diagram, was connected to the mentioned pins. All connections were made using jumper wires, with one end without headers and soldered together with the resistors for the pushbuttons. The LCD keypad shield was connected with original jumper wires without modification, while for the speakers, the jumper wires were modified for easy connection.

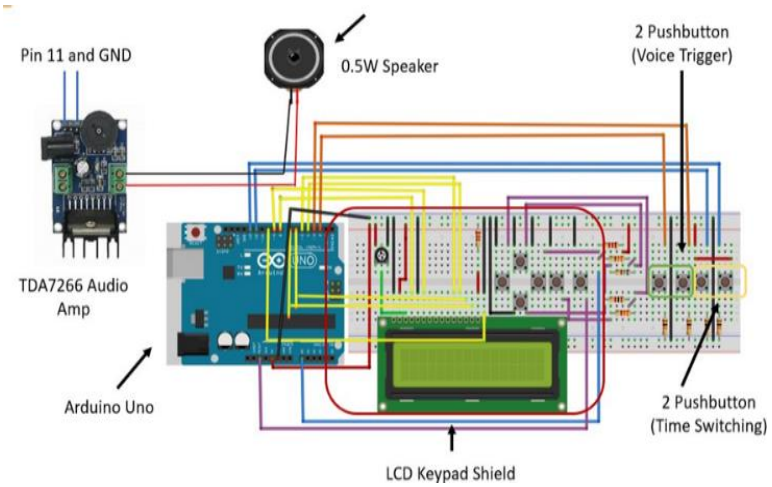

Figure 2. Schematic circuit for hardware components.

The outer case was constructed and designed using black polypropylene (PP) plate sheets to house and secure all the components within it. The case is designed to resemble a traditional chess clock. Figure 3 depicts the design of the casing for the digital chess clock tailored for visually impaired chess players.

Figure 3. Casing design of digital chess clock for visually impaired chess players.

3. RESULTS & DISCUSSION

A finalized prototype of a digital chess clock for visually impaired chess players was constructed and tested. As depicted in Figure 4 (a), the prototype comprised two mini pushbuttons for time switching, two push buttons on each side for triggering time announcements for each player, and an LCD keypad shield for displaying and setting the time. The back view of the prototype is illustrated in Figure 4 (b), revealing the attached 0.5W speaker for voice output and several holes for cable pathways connecting the controller and audio amplifier. The controller, an Arduino Uno, was powered by a power bank, while the audio amplifier was powered by an adapter capable of providing sufficient voltage output. Figure 4 (c) and Figure 4 (d) present side views of the prototype, featuring a pushbutton on each side as a trigger for voice output.

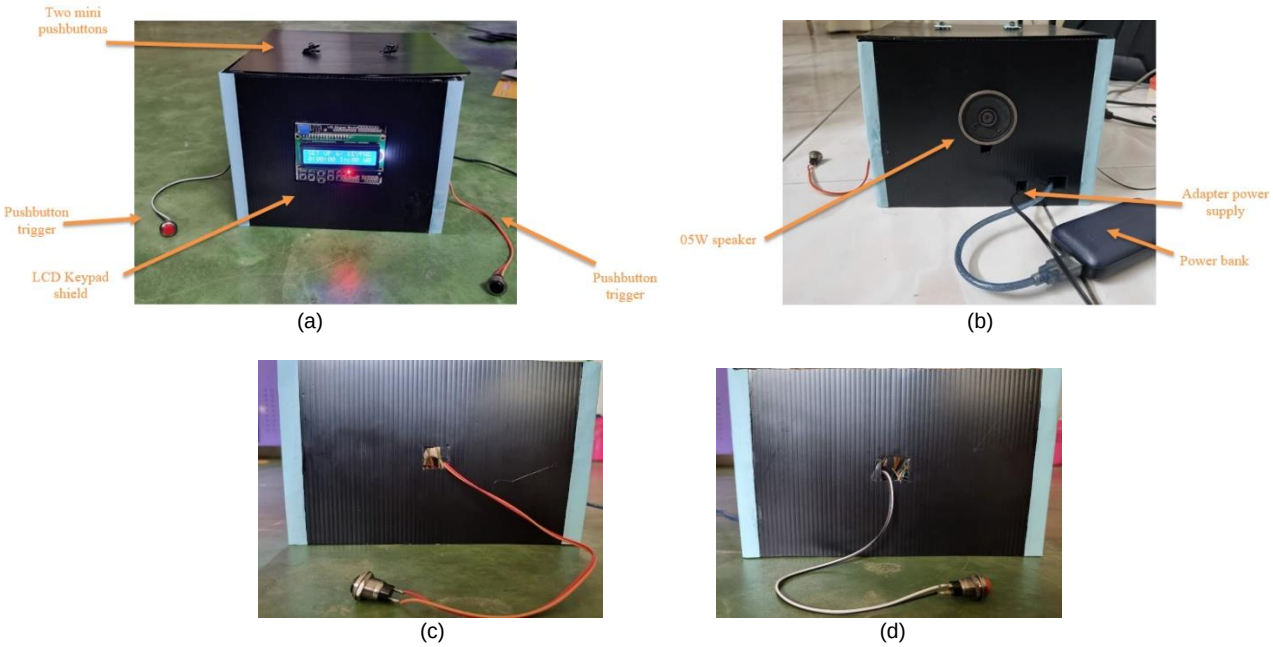

Figure 4. (a) Prototype of digital chess clock from (b) back view, (c) left and (d) right views.

3.1 Operation of Digital Chess Clock

Figure 5 (a) displays the initial screen upon powering the device, featuring the message 'Talking Arduino Chess Clock' to signify the purpose of this prototype. The subsequent stage is the setup menu, illustrated in Figure 5 (b). Within the setup menu, the first line indicates 'SET UP W/ KEYPAD,' prompting users to configure the timer using the keypad of the LCD keypad shield. The second line presents the timer details, including hours, minutes, and seconds, along with the increment value and player side. Time configuration is facilitated using the keypad; for instance, in Figure 5 (c), the timer is set to 20 minutes, a common duration for a chess match, with an increment value of zero. Once configured, the display transitions to the chess clock timer screen, depicted in Figure 5 (d). Here, the first line indicates the placement of white and black pieces, with the increment value displayed in the middle. The second line showcases the timers for both the white and black sides. Figure 5 (e) illustrates the current time running for both players during the chess match. In Figure 5 (f), the voice trigger buttons for both the white and black sides are pressed, resulting in the vocalization of the timing while the timer is paused. Once the timing for both players is announced, the timer resumes.

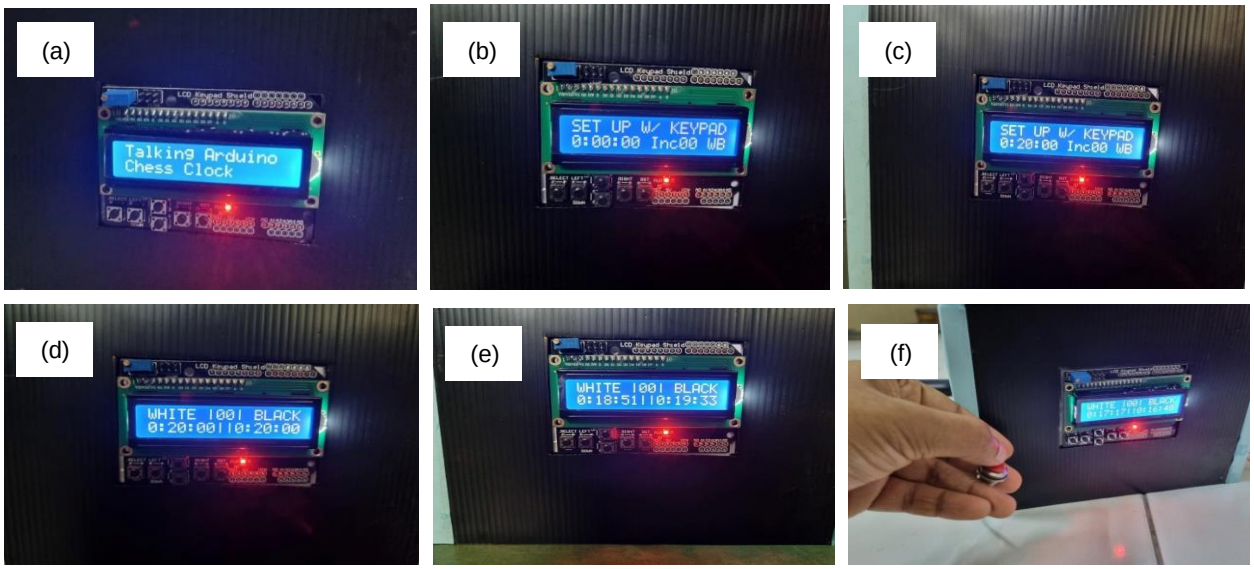

Figure 5. (a) Initial display, (b) setup Menu display, (c) timer was set to 20 minutes with increment zero, (d) chess clock timer screen, (e) players time running during playing and (f) white and black side trigger button pressed.

3.2 Testing and Analysis

The digital chess clock prototype underwent testing with four visually impaired chess players at the beginner level, each possessing knowledge of chess playing and experiencing visual challenges. Following the completion of each match, every player participated in an interview answering three questions related to the digital chess clock prototype. Table 2 provides an overview of the questions posed and the corresponding responses for each player. As depicted in Table 2, all players were able to audibly perceive the remaining time of both players during the match, demonstrating the effectiveness of the prototype in providing essential timekeeping information. Additionally, all players successfully managed to track the time throughout the chess matches. However, the majority of players expressed dissatisfaction with the clarity and distortion of the voice output. Furthermore, many found the buttons utilized for time switching to be excessively small and challenging to locate. These insights, gathered from the prototype testing, highlight areas for potential improvement and refinement in future iterations of the digital chess clock design.

Table 2. Questions and Responses of the visually impaired chess players.

	Responses			
Questions	**Player 1**	**Player 2**	**Player 3**	**Player 4**
Is the time of the players can be heard?	Yes	Yes	Yes, but less clear	Yes, able to hear but have abit of distortion
Is it comfortable to use the digital chessclock?	Not really the time switch button was small	Ok the button could be bigger	Yes, it was	Yes, able to hear but not clear
What improvements would you suggest?	Bigger buttons and clearer audiooutput	Bigger button	Clearer audio	Better quality audio
Were you able to track the time duringthe match?	Yes	Yes	Yes	Yes

The prototype of the digital chess clock for visually impaired players was successfully designed and constructed, and its functionality was evaluated through testing with beginner-level visually impaired chess players. As indicated in Table 2, one of the identified drawbacks of this prototype was the unclear sound output (6). This issue stems from the limitations of the Talkie library, which utilizes fixed vocabulary encoded with LPC (Linear Predictive Coding). Consequently, the built-in words or libraries often exhibit lower quality and distortion. These sounds are then converted into hex code for processing by the Arduino controller (7).

To address this challenge, one potential solution is to incorporate an additional module to mitigate sound distortion or to develop custom words and sounds tailored to specific requirements. However, this approach may be time-consuming as it involves creating new sounds from scratch. Despite these challenges, the players were still able to perceive the time of both players audibly. Another issue observed during testing was the small size of the mini pushbuttons, which hindered players from effectively switching the time. Introducing larger-sized pushbuttons into assistive devices like this chess clock could offer significant benefits beyond chess tournaments. Such enhancements would not only improve accessibility for visually impaired individuals but also benefit those with motor impairments or dexterity issues.

4. CONCLUSION

In conclusion, while the prototype demonstrated promising functionality, addressing the issues related to sound quality and button size could further enhance its usability and effectiveness for visually impaired users. The digital chess clock may help impaired visual players to keep track of the remaining time during chess matches, as demonstrated by this study's voice output feature for both players. Specifically, the clock is anticipated to be particularly beneficial in various chess tournaments, ultimately fostering the inclusion and participation of blind chess players within the chess community. However, the implementation of this digital chess clock requires consideration of its unclear and loud voice output. Future works could focus on enhancing the clock's output by incorporating an audio jack headphone system to mitigate noise disturbances that may affect other players in the vicinity.

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CONFLICT OF INTEREST

The authors have no conflict of interest.

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