Gesture-Based Elevator Control System

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Abstract

Since the onset of the COVID pandemic we have come to realize the importance of touch-less systems. The health risks that come from everyday usage of public touch-based information systems have entered public awareness. These systems also have the added drawback of being expensive and unsuitable for use in third world countries. We need systems that are intuitive to novice and semi-educated users, using cost-effective components that can be integrated into modern systems. In response to these problems we have developed an elevator management system which uses finger gestures, one of the most natural forms of communication. This system utilized low cost LDR sensors and LEDs to detect finger gestures via reflection of light. The system was tested to handle different corner cases for elevator systems and designed to work with minimal user guidance.

Acknowledgement

The cardinal credit goes to our supervisor A. B. M. Alim Al Islam who helped us through each stage from the conception of idea, designing a working model and finally polishing the system. Besides we are also grateful for our course teacher Md. Tareq Mahmood who guided us in selecting the proper hardware actually necessary for our project. Still we faced many problems in purchasing the hardware we wanted because of persistent lockdowns and limited movement allowance. During this time some of our seniors came forward and helped us by providing the requisite components.

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1 Introduction

Public information management systems are ubiquitous in developed countries and are rapidly popping up in developing countries as well. These systems are used by hundreds of users on a daily basis and thus prove to be a health risk. Again a significant majority of these users are semi-literate and may face difficulties using complex technologies.

We need systems that are intuitive to novice and semi-educated users, using cost-effective components that can be integrated into modern systems.

Our system uses finger gestures, one of the most natural forms of communication. The basis of this system is two low cost components - LED and LDR. The LED was used to emit light and LDR detected that light after being reflected from an object. These two form a coupling and each coupling is used to detect finger gestures which indicate our floor count. The system then displays the output via LCD monitor and finally send the result to existing system interface. These components are widely available and very low cost. We have also designed the system to allow simultaneous multi-digit input, input reset, elapsed time display to make the system as intuitive as possible.

Our system is primarily a prototype for elevator management. But this work can similarly be extended for other public information management system applications. We can also extend variety and complexity of gestures by adjusting the number of couplings. The system was calibrated for a specific environment but can be further tested in different environments to make the system robust.

2 Background

The idea of the project came from the ongoing covid-19 situation. The virus that causes COVID-19 is mainly transmitted through droplets generated when an infected person coughs, sneezes, or exhales. These droplets are too heavy to hang in the air, and quickly fall on floors or surfaces. You can be infected by breathing in the virus if you are within close proximity of someone who has COVID-19, or by touching a contaminated surface and then your eyes, nose or mouth.[1]

The elevators that are being used in our country are mostly touch-based. You need to press several keys to call the elevator and go to certain floor. This increases the risk of getting affected by the COVID-19 virus. So, we thought of a project to make the whole process touch-less.

Overall, research into gesture-based systems is fairly immature and has received limited attention by the community. T. Ishikawa et al. introduced a touchless input device and gesture commands for operating a PC[3]. Francisco Bianor de Medeiros et al. made an input device with capacitive sensors that can detect hand movement without touching its surface[4]. We were heavily influenced by Tusher Chakraborty et al.'s Sporshohin: A Tale of Devising Visible Light Based Low-Cost Robust Touchless Input Device[2]. They worked with photo transistor-LED couples to detect gestures, we used LDRs instead. This prototype suggests a low-cost solution for touchless input systems that can be applied for many other fields other than the field we worked on.

3 Project Design

3.1 Circuit Diagram and Code

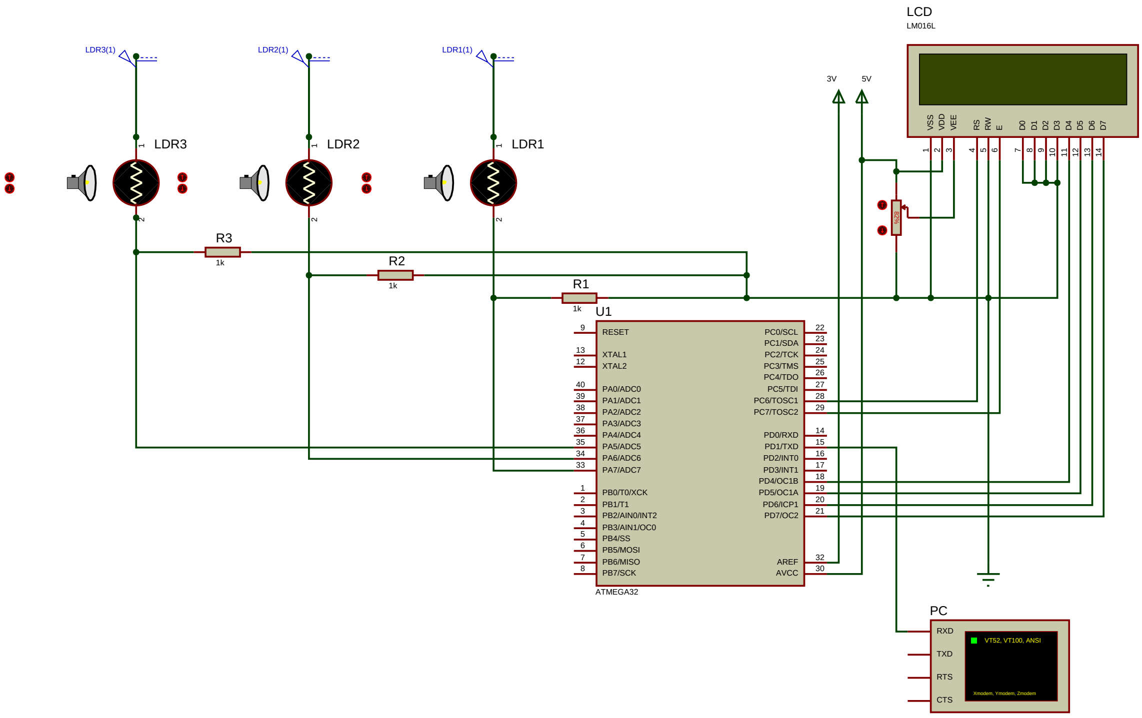
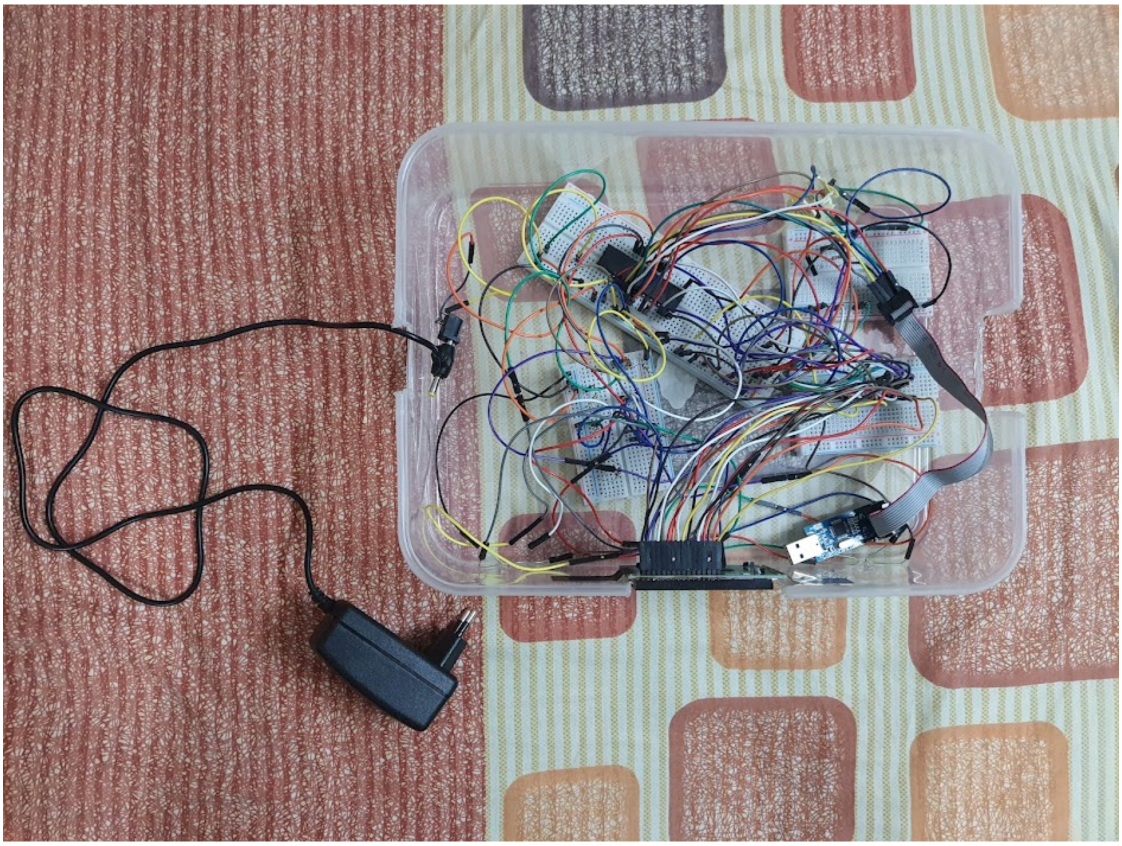
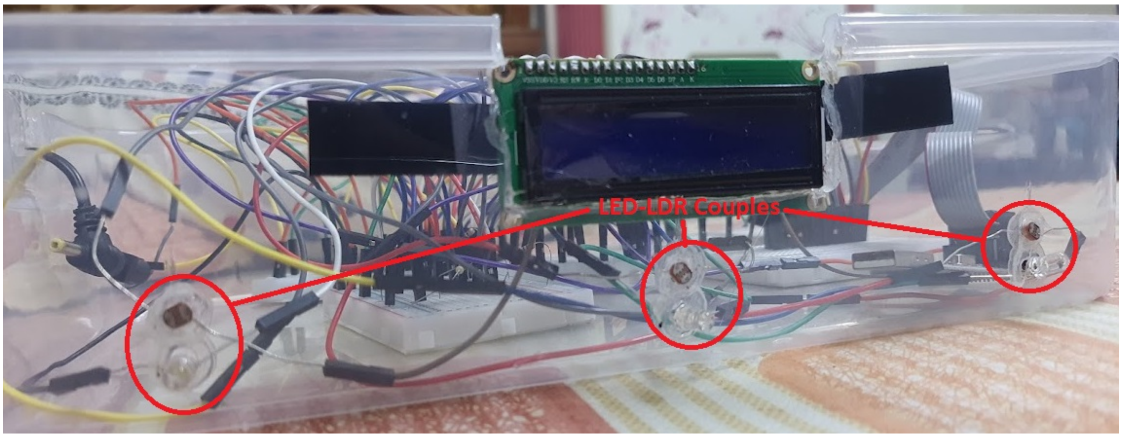


Figure 1: Circuit Diagram

This simulation is done in Proteus 8 Professional. In the actual circuit white LED is used in place of the torch in the Figure 2b. The finger gestures are simulated by movement of the torch which increases/decrease the light intensity. The LCD display immediate feedback and the virtual terminal displays the final response. Two figures of the real circuit are attached here. All the codes are available in Github [5].



(a) Top View



(b) Front View

Figure 2: Implemented Circuit

3.2 Working Procedure

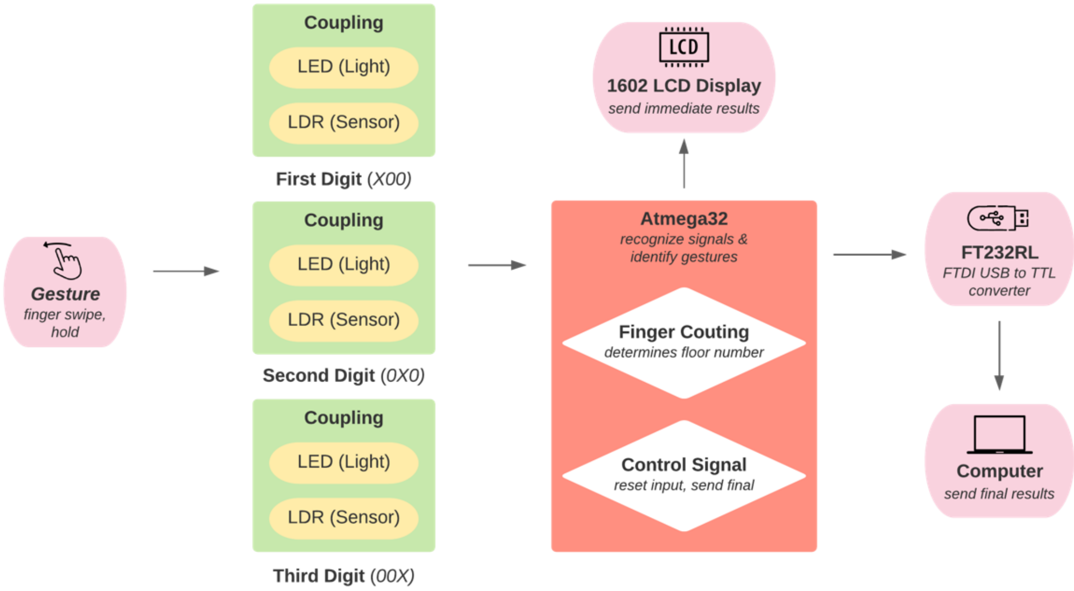


Figure 3: Block diagram

- Floor count starts from one, as we found it difficult to manage the ground floor(GF).
- You have to swipe your finger before a couple to change the corresponding digit(Leftmost couple for the MSB and so on). You have to swipe close enough(at most 1cm) to reflect the light from the LED to the LDR, otherwise nothing will be changed.
- Before your last input swipe, keep in mind that you have to keep the finger there for six seconds. If you remove the finger the system will keep taking input.
- If you made a mistake during input do nothing for six seconds and the floor count will be reset-ed.
- The "Time:" section in LCD (Figure 5) shows time spent after the last swipe. if nothing is in front of it, it will reset after six seconds. If a finger is before any of the couple for six seconds it will send the input to the PC.

- LDR(Light Dependent Resistor) works with light. When the place is dark its resistance increases on the other hand resistance decreases in presence of more light (Figure 4). We used this feature for our project. When anyone swipes his/her finger before it, light gets reflected by the finger upon the LDR and resistance decreases. It is connected with another resistance of 5.6k Ω in series. So, when the LDR's resistance decreases the other resistor's corresponding voltage increases. We saw it crosses the 3V line when the finger is swiped. So, we picked it as the threshold.

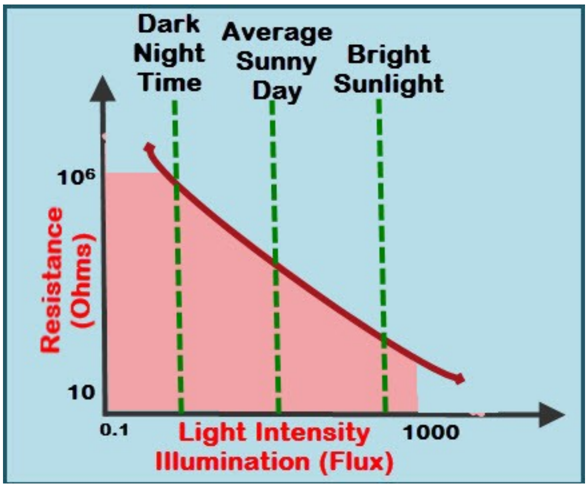


Figure 4: LDR: Light Intensity vs LDR Resistance[6]

- The voltage across the other resistor is read and processed by ADC pins and codes inside ATmega32. The floor count increment or reset and sending it using UART protocol are also done by the code.

- The results are shown in a 16*2 LCD display.

- A ft232rl USB to TTL device is used to communicate with the PC.

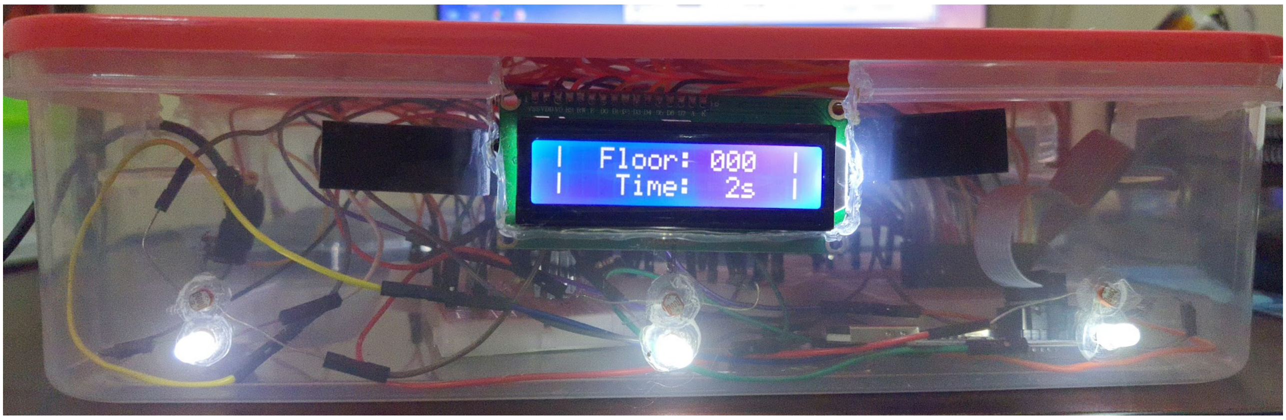


Figure 5: Working GBECS

3.3 Components and Cost Analysis

Item	Unit Price(BDT)	Unit	Price(BDT)
ATmega32a	320	1	320
LDR	5	3	15
White-LED	1	3	3
$16 * 2$ LCD Display	120	1	120
USBASP Programmer	350	1	350
FTDI USB to TTL Serial Converter Adapter FT232RL	300	1	300
Bread Board	50	4	200
AC to DC Adapter(5V)	70	1	70
Resistors	0.2	10	2
Jumper Wires	45	3	135
Total			1515

Table 1: Components and cost analysis

This(1515 BDT, 17.9USD) is the cost of the unit we made. If it is made commercially the production cost will be lesser.

4 Calculation and Result

Calculating Threshold Voltage in the LDR

We used LDRs in our project. Change in the resistance of each LDR would change the voltage dropped through it. We used this to detect fingers in front of the LDR-LED couple. If the voltage rises above a threshold amount,we would consider that a finger has been swiped. To calculate the threshold voltage, we used voltage dividing rule in the LDR-resistance shown in Figure 6. If we recall, the voltage divider rule denotes the voltage across the Resistor as

$$Voltage_{Resistor} = \frac{Resistance_{Resistor}}{Resistance_{LDR} + Resistance_{Resistor}} \times Voltage_{in}$$

Here the values we used are given below -

$$Voltage_{in} = 5V, Resistance_{Resistor} = 5.6k\Omega$$

The threshold point of the voltage, when swiping the finger, was found to be 3V.

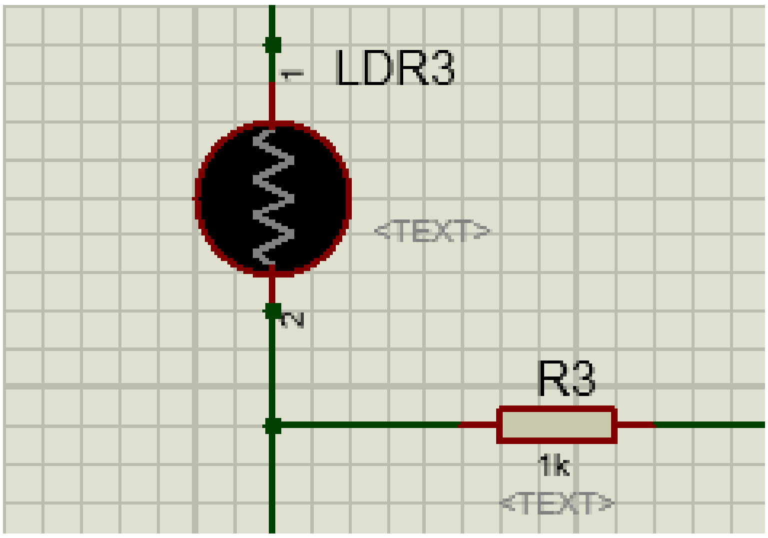


Figure 6: LDR-Resistance

Calculating Threshold Distance for Gesture

We had to measure the perfect distance from where we can use gestures so that the LDR-LED couple works fine. In this case we had to go through trial-and-error process to precisely measure this distance. The optimal distance we found after our calculation is ***one cm***, which can obviously vary if the environment changes

Calculating the Time to Keep On or Away the Fingers

In our project, we used the amount of ***six seconds*** time to process the results of the system. That means, we have to keep our finger for six seconds to transfer the data to the processor, or keep away our finger for six seconds to reset the data. Although this might seem an arbitrary value, still we think this to be optimal as anything less or more might affect the user-friendliness.

5 Discussion

The idea of controlling an elevator with a micro-controller was very intriguing. However, some issues arose as expected.

First we tried to deal with people moving or walking infront of the system. For this we have tuned the threshold voltage and distance in a way such that movement behind the threshold distance would have no effect on the system. We have already talked about it in the previous section.

Next, the effect of outside light source was to think about. We have placed the LDR-LED couple in such way that the other light sources would have very little effect on it and wouldn't be enough to change the voltage of the LDR.

We faced some problems in purchasing proper hardware because of persistent lockdowns and limited movement allowance. We intended to use the PL2303 USB-to-TTL converter and even placed the order but could not get the delivery. We had to finally make do with FT232RL which we borrowed from our senior.

6 Conclusion

Our intention was to build a low-cost project using commonly available components. We can easily implement this system in any elevator even in the most under-developed countries. The elevator buttons are among the few most vulnerable surfaces for contagious diseases like COVID to spread. Contact with such surfaces followed by contact with eyes, mouth or nose can lead to wide spread of these diseases. So if we eliminate the need to touch elevator buttons, then we can significantly reduce the possibility of being affected by COVID or any other similar virus. However, there are some challenges in introducing any new system to the public. But given a few trial and errors and some iterations we believe such systems can be brought into practical public use.

7 Reflection on Learning

Through this project we learned how to deal with the microcontrollers, sensors and other relevant hardware tools. We learned simulations and hardware implementation are quite different with their own advantages and caveats. There are many challenges which we had to face and we learned something new from overcoming each of these challenges. Here we note some of them:

1. Learn the structure of microcontrollers (Atmega32) and interfacing with various hardware components.

2. Convert C code using Atmel Studio to hex code and burn that to Atmega32 using USBAsp.

3. Learn the configuration and interfacing for LCD display.

4. Learn the use of sensors (LDR) and performing object detecting from the presence of fingers.

5. Learn to debug various hardware problem like loose connections, faulty interfacing and power issues.

8 Future Work

The recent pandemic has reminded us of the dire consequences of infectious contagious diseases. The most vulnerable sources of transmission are money, public trasports etc. This is why we think that touch-less public information systems like ours can be of great benefit. We can even extend our system for similar use cases like ATMs and vending machine where we have to touch surfaces for inputs.

References

[1] *Emerging Research in Healthcare COVID-19 —— Journal of clinical research* https://www.hilarispublisher.com/special-issue/emerging-research-in-healthcare-covid19-489.html.

[2] Tusher Chakraborty, Md. Nasim, Sakib Md. Bin Malek, Md. Taksir Hasan Majumder Sami, Mohammed Samiul Saeef, and A. B. M. Alim Al Islam. 2016. *Sporshohin: A Tale of Devising Visible Light Based Low-Cost Robust Touchless Input Device.* In Proceedings of the 7th Annual Symposium on Computing for Development (ACM DEV '16). Association for Computing Machinery, New York, NY, USA, Article 1, 1–10. DOI:https://doi.org/10.1145/3001913.3001914

[3] T. Ishikawa, Y. Horry and T. Hoshino. *Touchless input device and gesture commands.* 2005 Digest of Technical Papers. International Conference on Consumer Electronics, 2005. ICCE., 2005, pp. 205-206, doi: 10.1109/ICCE.2005.1429789.

[4] F. B. d. Medeiros, F. Davin, A. Barros and R. Dantas, 2018. *Senseboard: A Touchless Input Device for Hand Motion Detection.* 20th Symposium on Virtual and Augmented Reality (SVR), 2018, pp. 248-252, doi: 10.1109/SVR.2018.00008.

[5] *Gesture Based Elevator Control System.* GitHub. https://github.com/swargo98/Gesture-Based-Elevator-Control-System.

[6] *WatElectronics. (2019, July 18). Light dependent resistor (ldr) - working principle and its applications.* https://www.watelectronics.com/light-dependent-resistor-ldr-with-applications/.