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DEVELOPMENT OF A SHOOTER GAME CONTROL SYSTEM ON A DESKTOP-BASED INTERFACE USING ARDUINO UNO AND IMU SENSORS

Aris Sudaryanto [*1], Bunga Adinda[2], Hafazah Kano Sukamto[3], Kezia Vallerie Hartono[4], Sevtian Bintang Yoda[5], Tiara Satyawira Pratiwi[6]

[1,2,3,4,5,6]Teknologi Game, Politeknik Elektronika Negeri Surabaya, Indonesia

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ABSTRACT

Currently, there are various control systems available that can be used for games that can increase user interaction with the game being played. The use of this control system utilizes interface technology to facilitate user interaction. With a control system and an easy-to-use interface, the games that are presented will be more interesting and fun to play. The research was conducted with the aim of developing an interactive control system for shooter games on a desktop interface using Arduino Uno and IMU sensors. The research was developed using the Arduino Uno hardware connected to the IMU sensor and then integrated with the Arduino IDE as the main control for camera rotation and the user's point of view in the game interface. After conducting several experiments on users, the research concluded that the Arduino Uno device is easy to use as a control system with appropriate camera rotation and a clearly visible game interface.

Reseach Paper

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Keywords: Arduino, Game, IMU sensor, Interface, Shooter.

INTRODUCTION

The emergence of technology has changed human civilization to become more modern and continues to develop without stopping (Gills & Morgan, 2020). One of the technologies currently being developed is the control system and interface used to operate computers and their applications. A control system or control system is a collection of several components connected, thus forming a specific goal, namely controlling or managing a system (Sudrajat & Rofifah, 2023). At the same time, the interface receives information from the user and can convert it into a form that the system can accept. In addition, the interface also receives information from the system and presents it in a form understandable to users (Jabbar et al., 2019). The control system can be developed effectively if integrated with an easy-to-use interface. The two things are interconnected to make it easier for the user to operate a computer or other work.

An example of using a control system is a mouse that moves the cursor on the screen, a keyboard that is used to display letters or type, and also in-game applications or games as a controller (Rosyid et al., 2021). Game is a form of entertainment often used as a refresher for the mind from the fatigue caused by our activities and routines (Zhang & Qin, 2021). Developments in the game world are also very

* **Correspondence Address**
E-mail: bunganyx@gt.student.pens.ac.id

rapid, as evidenced by various types of new games, game markets in great demand by users, and the emergence of various interesting technologies for playing games (Sarwat et al., 2023). In a game, various technologies are generally applied, one of which is the control system and game interface. Ghost Squad is an example of a game that uses a controller when playing (Oscar et al., 2018). The controller is a handgun connected to the console and functions to send data like a mouse (Applewhite et al., 2021). However, the controller in similar games only directs the weapon at the target point without changing the user's point of view. This shows that game interactions like this have existed since the early 2000s and are considered less interactive nowadays. Therefore, researchers took the initiative to reduce boredom in playing shooter games by creating a more interactive control system.

Based on research conducted by Zanofa et al. (2020) regarding a desktop-based control system using Arduino Uno and IMU Sensors, it can increase player creativity and minimize player saturation levels. Satya et al. (2020) also expressed the same thing but using the ACS712 sensor. The results are that the errors obtained are relatively small from using the ACS712 sensor, so it is known that this can increase the sensitivity of future shooter games. He also mentioned that using Arduino Uno can increase the positive impact on its users. Then Gujarathi & Bhole (2019) states that the IMU sensor is easier to operate, and significant results are obtained from the analysis.

Based on the above empirical results, the authors are interested in researching a shooter game control system on a desktop-based interface using Arduino Uno and IMU sensors. Integrating Arduino and IMU sensors into the desktop interface is expected to enable users to play more efficiently and interactively. The control system uses the IMU sensor as a reference for controlling camera rotation and user perspective in this shooter game, "Piggy Donuts." In Piggy Donuts, the user has to shoot donuts at pigs that are scattered in an area. The user is given two minutes to feed the pigs by shooting donuts. Users can interact with games using Arduino, which has been connected to a computer device.

LITERATURE REVIEW

There are several other studies related to the use of Arduino Uno and IMU sensors. One of them is research entitled "Tray Stabilization System Using IMU Sensors and Arduino Nano." The IMU sensor measures speed, orientation, and gravitational force using an accelerometer and gyroscope sensor (Ruanagara et al., 2022). The gyroscope sensor in the IMU is used in the Piggy Donuts game to detect movements according to gravity or user movements. The study entitled "A Wearable Device for Enhancing Basketball Shooting Correctness with MPU6050 Sensors and Support Vector Machine Classification" also uses IMU sensors (Fadillah et al., 2022).

The device being developed is a smartwatch to classify the right or wrong technique of shooting a basketball with the help of a gyroscope and accelerometer sensor. The gyroscope sensor will record angular velocity data when the smartwatch rotates, while the accelerometer sensor works as a gauge and recorder of the acceleration of movement of body parts. In addition, IMU can also be used in software development to visualize the range of motion of objects by reading and managing streaming data from navigation sensors (accelerometer and rate-gyroscope). The device was developed in a study entitled "3D Animation of Aircraft Movement on the Apron and Runway" (Retnowati et al., 2016).

As for research using Arduino, one of them is in the study entitled "Functional Test of Arduino-Based Body Temperature Measurement System Using the Blackbox Testing Method." This study uses Arduino as a body temperature system with the help of infrared sensors. The resulting tool will measure the user's temperature without contact using a temperature sensor, and then body temperature data will be displayed on the LCD. Arduino can program and process output based on the input provided (Vostrukhin & Vakhtina, 2016).

In addition, Arduino Uno can be used as the primary control of the sensor system in a study entitled "Design of Arduino-Based

Clothesline Protection with Rain Sensors and Light Sensors." Arduino UNO can control a light sensor to see the intensity of sunlight and a rain sensor to determine whether it is raining (Harianto et al., 2022). In addition to the temperature control system and clothesline protection, several other systems can be developed using Arduino, one of which is the Piggy Donuts game.

Testing Arduino Uno and IMU sensors in the Piggy Donuts shooter game can use the usability testing method. Several studies discuss this method. One is a study entitled "Website Interface Evaluation of SMK Muhammadiyah 2 Sragen using the Usability Testing Method". This study discusses usability evaluation to determine convenience, comfort, and satisfaction when using the school's website to determine whether the system will be helpful to, accepted by users, and last a long time in its use (Kularbphettong et al., 2019).

There are several other studies regarding usability testing. The research entitled "Usability Evaluation of the My Telkomsel Application Using the Usability Testing Method" discusses usability evaluation using the five available criteria: learnability, efficiency, memorability error, and satisfaction in the My Telkomsel application (Pramono et al., 2019). The method used can collect various problems and find various solutions for researchers so that the My Telkomsel application can be easier to use. Usability testing is also discussed in a study entitled "A Usability Testing of a Higher Education Mobile Application Among Postgraduate and Undergraduate Students."

This study uses usability testing standards based on ISO 9241-11 standards to measure three usability factors: effectiveness, efficiency, and satisfaction in the Higher Education Mobile Application (Ahmad & Hussaini, 2021). There is also research entitled "Evaluating User Experience of a Mobile Health Application Halodoc using User Experience Questionnaire and Usability Testing," which uses the UEQ method and usability testing to obtain an evaluation of the user experience of the Halodoc application. That way, developers can overcome UX problems from the Halodoc application by considering usability goals and user experience (Kushendriawan et al., 2021).

METHODS

The methodology used in this research is usability testing and functional testing. Usability testing in this study was carried out by direct testing and filling out questionnaires by the user. Meanwhile, functional testing is done by testing the button functionality on the Piggy Donuts game application one hundred times for each button. Usability and functionality testing is carried out after completing the experimental phase. The experimental stage begins by connecting the Arduino Uno to the IMU sensor using a male-female jumper cable soldered so that the two devices can be permanently connected. Next, Arduino will be connected to the computer device used to play.

Arduino will be given the command to read rotation data from the IMU sensor with pseudocode in Arduino IDE software. Next, an examination is carried out on the monitor system to check whether the IMU sensor rotation is appropriate. She was followed by creating an IMU sensor program in Unity 3D, which is integrated with the user's camera. Lastly, I added designs and interface buttons that are easy and attractive to the user to create an attractive interface.

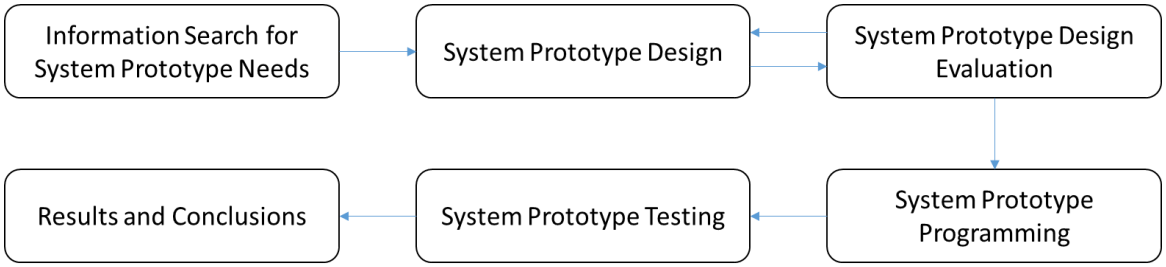

Figure 1. Experimental Process Method

Figure 1 shows a diagram of the experimental process of making a game control system on a desktop interface using Arduino Uno and IMU sensors. The stages in this research are as follows:

Connecting Arduino Uno with IMU Sensors

The first process that must be done is connecting the Arduino Uno and the IMU sensor. Sockets that are connected include VCC, GND, SCL, and SDA. **Figure 2** shows the Arduino Uno circuit with the IMU sensor. Finally, the Arduino circuit and IMU sensor are connected to the computer device. Arduino that has been connected is indicated by the LED that lights up.

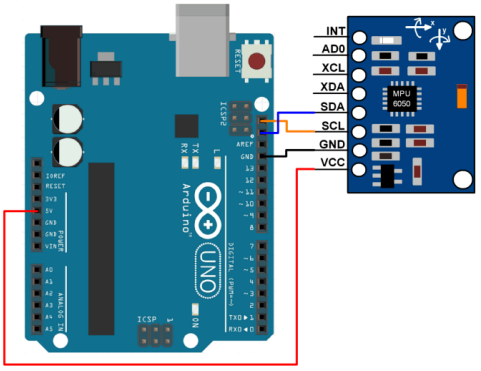

Figure 2. Arduino circuit with IMU

After connecting with the IMU sensor, then Arduino is programmed to read the camera rotation movement according to the user-driven controller shown in **Figure 3**.

```
// MPU control/status vars
bool dmpReady = false;  // set true if DMP init was successful
uint8_t mpuIntStatus;   // holds actual interrupt status byte from MPU
uint8_t devStatus;      // return status after each device operation (0 = success, !0 = error)
uint16_t packetSize;    // expected DMP packet size (default is 42 bytes)
uint16_t fifoCount;     // count of all bytes currently in FIFO
uint8_t fifoBuffer[64]; // FIFO storage buffer

// orientation/motion vars
Quaternion q;           // [w, x, y, z]         quaternion container
VectorInt16 aa;         // [x, y, z]            accel sensor measurements
VectorInt16 aaReal;     // [x, y, z]            gravity-free accel sensor measurements
VectorInt16 aaWorld;    // [x, y, z]            world-frame accel sensor measurements
VectorFloat gravity;    // [x, y, z]            gravity vector
float euler[3];         // [psi, theta, phi]    Euler angle container
float ypr[3];           // [yaw, pitch, roll]   yaw/pitch/roll container and gravity vector

// Calibration Time: generate offsets and calibrate our MPU6050
mpu.CalibrateAccel(6);
mpu.CalibrateGyro(6);
mpu.PrintActiveOffsets();
// turn on the DMP, now that it's ready
Serial.println(F("Enabling DMP..."));
mpu.setDMPEnabled(true);
```

Figure 3. Program on the Arduino IDE

In order for the rotation data from the IMU sensor to be read by the game, a program was created in this study using C# which can be seen in **Figure 4**.

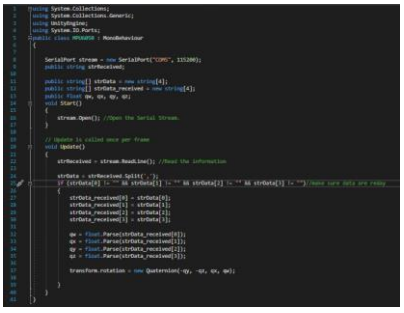

Figure 4. Program to Retrieve Data

Rotation data from the IMU sensor is then used as a reference in controlling camera rotation, which can be seen in **Figure 5**.

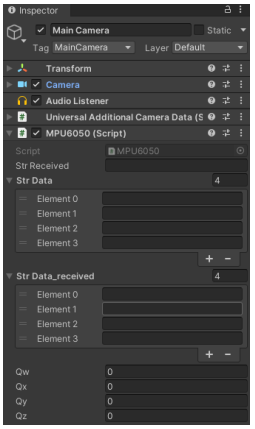

Figure 5. Inspector Object on the Camera

The next step is to create a child object within the camera object to fire the projectile. That way, the projectiles that are ejected will always aim at the front of the camera. Then the projectile is fired when the user presses the left button on the mouse which can be seen in **Figure 6**.

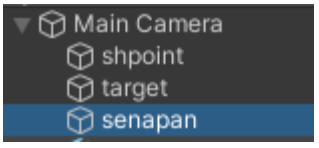

Figure 6. Hierarchy of Objects

So, in this shooter game the camera plays a big role for the user to direct the target of the shot.

RESULTS AND DISCUSSION

Making the interface in the game is presented through a GUI flowchart which can be seen in **Figure 7**.

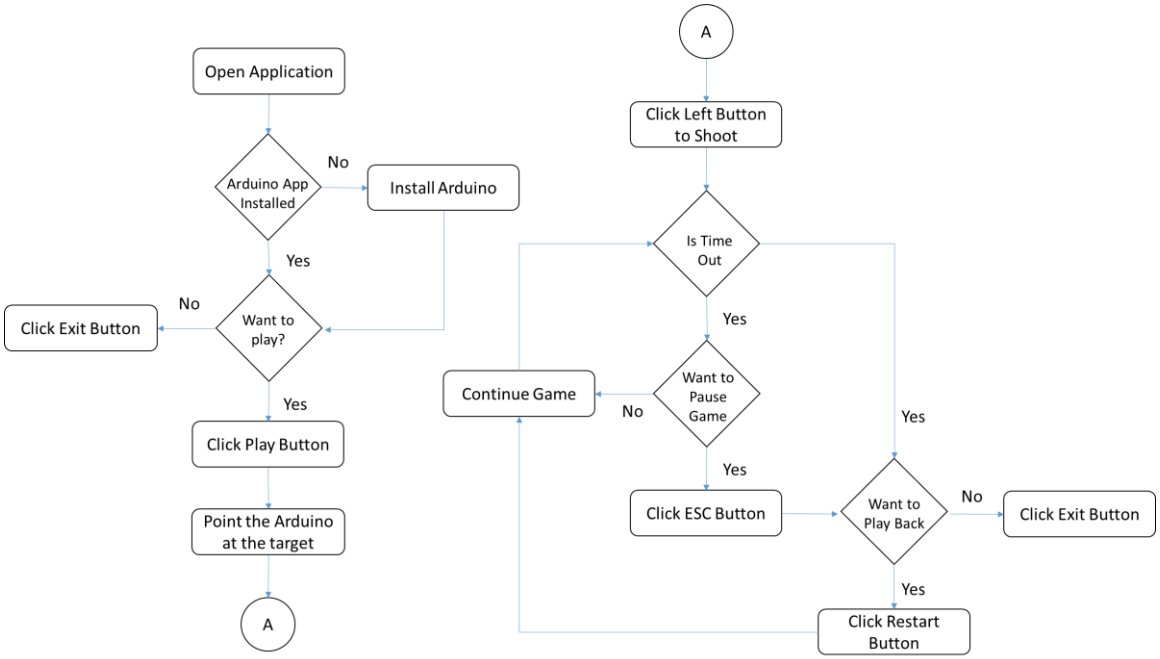

Figure 7. GUI flowchart

Figure 7 is the flow of the game interface starting from the installation of the control system device. Then open the game and interact with the main menu, which displays the play and exit buttons. If the user wants to start the game, he can press the play button and enter the arena. The user can press the escape button to pause the game, and a pause menu will appear, which pauses the game. In this menu, there is a resume button that functions to continue the game, and then there is also an exit button if the user wants to exit the game. The game will automatically end in two minutes with a "Time Out!" notification.

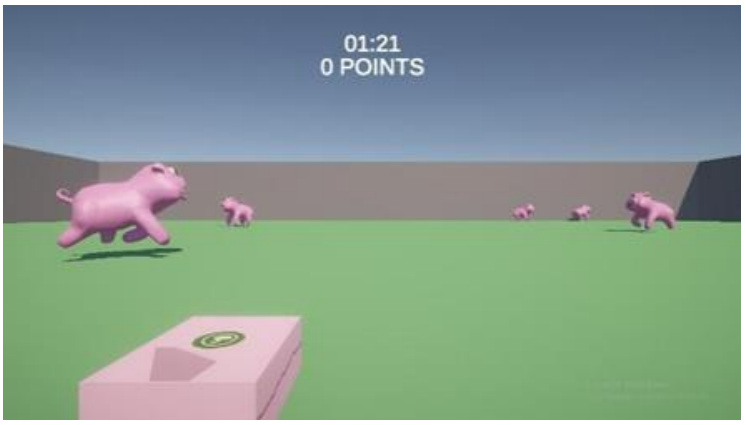

Figure 8. Artificial Intelligence as a Target in Games

It can be seen that in **Figure 9** it is known that researchers added features to add excitement to the game, we created an artificial intelligence that can move freely so that the user has to direct his target to the moving object. Furthermore, we also make the interface look attractive and not difficult for the user by using buttons that are clearly visible for the opening screen and pause when playing.

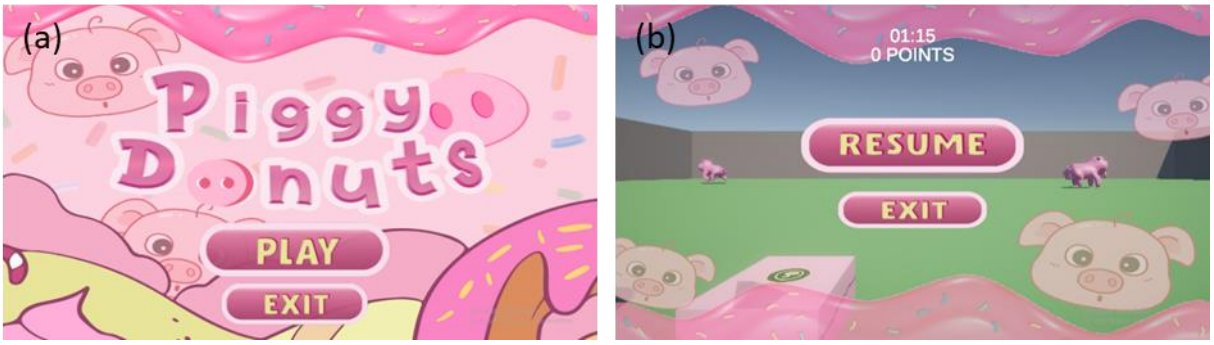

Figure 9. Menu in Game (a) Main Menu (b) Pause Menu

The Arduino test uses 10 participants who play Piggy Donuts with our device. Arduino testing uses scenario assignments for participants to find information about Arduino functions. The task scenario is shown in **Table *1.* Task ScenarioTable 1**.

Table 1. Task Scenario

Num	Task
1	Doing a start button test.
2	Doing a pause button test.
3	Doing a test of the resume button.
4	Move the Arduino right and left and shoot at the target.
5	Testing the exit button.

Test data analysis is carried out by calculating the time needed by participants to complete all tasks contained in the task scenario. Time analysis is needed to evaluate Arduino's effectiveness as a game controller. The results of the controller test are shown in **Table 2**.

Table 2. Testing the Start-Exit Button

Respondents	Time (s)				
	Start	**Pause**	**Resume**	**Move**	**Exit**
1	5	8	6	7	15
2	6	6	1	74	2
3	9	10	3	96	3
4	14	19	2	94	2
5	5	2	2	127	2
6	7	8	4	88	8
7	7	5	4	124	2
8	10	6	2	125	3
9	10	3	2	124	3
10	10	5	4	126	4
Mean	**8**	**7**	3	**96**	**4**

From the test results in **Table 2**, it can be concluded that each task scenario shows a different time in each test. The average time resulting from testing the task scenarios answers that the respondents can understand the interface in the game. Furthermore, in the results of the move, it can be concluded that the Piggy Donuts game is suitable for using Arduino as a controller, judging from the relatively high average results of the respondents.

In addition to using respondents, we also tested the interface by trying 100 times to test the same button. Testing aims to ensure

that the in-game interface buttons function correctly. The interface button testing can be seen in **Table 3**.

Table 3. Interface Button Testing

Button	Success	Fail
Play	100	-
Exit (Main Menu)	100	-
Pause	100	-
Resume	100	-
Exit (Pause Menu)	100	-
Shoot	94	6

Questionnaire data analysis was carried out to determine the category percentage of groups based on the answers given by respondents to each question. The results of processing the questionnaire data as shown in **Table 4**.

Table 4. Questionnaire Data Processing Results

Question	%	Criteria
Is the Arduino device easy to use?	67%	Strong
Is Arduino suitable for use in the Piggy Donuts game?	77%	Strong
Are the Arduino's motion and the gun's direction compatible?	68%	Strong
How helpful is Arduino in gaining points in games?	73%	Strong
Do you think the camera's POV is comfortable to look at?	84%	Very strong
Do you think the enemy can be seen clearly?	93%	Very strong
Does rotation (right and left) make it easier to play games?	79%	Strong
What is the sensitivity level of the Arduino when playing?	78%	Strong
Is the UI clearly visible?	91%	Very strong
Do you think the symbols/pictures used in the game are easy to understand?	92%	Very strong

Table 4 shows data processing from the results of the respondent's questionnaire when playing Piggy Donuts with the Arduino media controller. The questionnaire results generally show that the main menu display is powerful, which is indicated by the majority of respondents' answers showing a value of more than 85% with vital to decisive criteria. Unsatisfactory results are seen in questions that are directly related to Arduino performance. Data processing shows sufficient criteria for the ease of participants seeing the UI of the game.

CONCLUSION

Based on this research, the interface of Piggy Donuts is excellent. This shows that Arduino implementation is effective in shooter genre games, as evidenced by the test results in the tables above. However, the compatibility of the Arduino's motion with the cursor in the game does not function perfectly, and a small percentage indicates this in the questionnaire results, which only reached 68%.

Author's declaration

Authors' contributions and responsibilities

The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation and discussion of results. The authors read and approved the final manuscript.

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Availability of data and materials

All data are available from the authors.

Competing interests

The authors declare no competing interest.

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