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CAMTRACK: A MOBILE-APPLICATION-CONTROLLED DEVICE FOR MULTIMEDIA CONTENT CREATION

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Abstract: **Mobile cameras have transformed how we document and share visual content, but limitations hinder creative capabilities. This study develops a cost-effective device controlled by a mobile app to enhance mobile camera capabilities. The device targets multimedia content creation as an affordable alternative to expensive app-controlled devices. The researchers designed and constructed a camera mount with rail guides and stepper motors, controlled through a mobile app. Thorough testing and evaluation assessed functionality, performance, reliability, maintainability, and usability based on ISO 25010 criteria. Stratified random sampling selected respondents such as content creators, photographers, and videographers who evaluated the prototype. The evaluation results yielded high scores, with a grand mean of 3.3333 for reliability, 3.6400 for maintainability, 3.7120 for usability, 3.3680 for performance efficiency, and 3.7160 for functional suitability, indicating a strong consensus among participants and demonstrating the high utility of the developed technology. Researchers recommend enhancing the CAMTRACK prototype with advanced camera devices, extended rail length, improved user interface, multidirectional movement, customizable camera settings, and enhanced battery portability.**

***Keywords*: Mobile cameras, visual content, multimedia content creation, technological advancement.**

I. INTRODUCTION

The digital era has ushered in a prolific surge of multimedia content creation and sharing, driven by the widespread adoption of smartphones, digital cameras, and social media platforms (Ahmad et al., 2019; Statista, 2023). With the exponential growth of multimedia archives, there arises an imperative need for automated tools that can efficiently organize, retrieve, and manage these vast and unstructured collections. Recent developments in event recognition have shown promise in addressing this challenge, offering a powerful solution to organize and categorize multimedia data (Ahmad et al., 2019).

Simultaneously, photography, as an art form, continues to hold immense significance, remaining an inseparable part of our daily lives (Tashmukhamedova, 2019). The ubiquity of cameras on smartphones and digital devices empowers individuals to capture and store moments effortlessly, resulting in a global surge of photography enthusiasts and social media engagement (Statista, 2023; Hallock et al., 2019).

However, the pursuit of high-quality and artistic photography goes beyond mere technical knowledge and composition principles. It demands an innate appreciation for the artistic process and a photographer's ability to conceptualize and convey their unique vision (Tashmukhamedova, 2019). As photography gains popularity, accessibility, and technological progress, the need to foster an artistic approach to this medium becomes increasingly critical. This research paper introduces an innovative camera accessory that seamlessly merges mobile applications' technology, redefining visual storytelling. The paper delves into its potential applications in multimedia content creation and artistic.

photography, underscoring the effectiveness of event recognition for streamlined organization (Ahmad et al., 2019). Furthermore, it underscores the significance of an artistic outlook in photography (Tashmukhamedova, 2019) and the role of social media platforms in amplifying artistic expression (Hallock et al., 2019; Statista, 2023). Through this exploration, we unveil the transformative impact of this versatile tool on the creative processes, empowering photographers to craft compelling visual narratives and solidify photography's enduring prominence in the digital age. CAMTRACK represents a dynamic fusion of technology and artistic ingenuity, providing unprecedented control and flexibility to elevate the art of photography and engage a global audience.

II. METHODOLOGY

A. Research Design

The research applied quantitative methodology, which involves the collection and analysis of numerical data to examine and quantify the relationships, patterns, and trends related to the research objectives. It utilized true experimental research design to gather all the data needed for this research and to seek a better understanding regarding the use of the developed mobile-application-controlled device. Under experimental design, the within-subjects design was used where data is collected from the same group of participants under different experimental conditions which is an excellent approach for prototyping method. This design allows the researchers to observe changes and make comparisons on each of the participant views, providing valuable insights into the effects of the variables being studied. The outcomes of this study are expected to expand the existing literature on mobile application devices and provide recommendations for further advancements in this area.

B. Respondents

The study involved the participation of social media content creators, and other individuals engaged in multimedia photography, including photographers and videographers. The study was conducted from June 2022 onwards, with the objective of assessing the functionality of the developed mobile-application-controlled camera device in the creation of multimedia content.

C. Project Construction

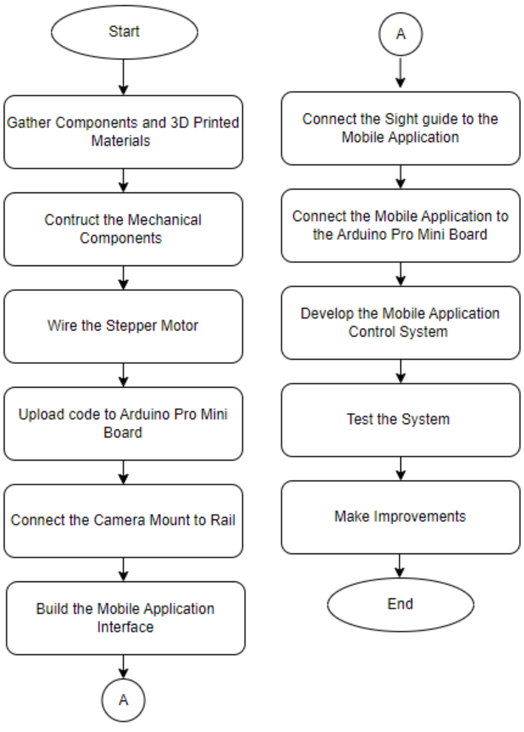

Figure 2.1: Project Assembly Flowchart

Steps in Project Assembly

Step 1: Gathering of Components and 3D Printed Materials- This step involves gathering all the necessary hardware components, software components, and 3D printed materials needed to build the prototype. These items should include a stepper motor, aluminum profile rail, an Arduino Pro Mini board, a stepper motor driver, a power source, 3D printed camera mount.

Step 2: Construct the Mechanical Components - In this step, attach the camera's baseplate to aluminum profile and mount the stepper motor to its carriage that moves along the rail. This creates the mechanical part of the prototype consisting of motors and different hardware components.

Step 3: Wire the Stepper Motor - This step involves connecting the stepper motor to the stepper motor driver and linking this motor driver to the Arduino Pro Mini board. This enables the motor to receive signals from the board and control the movement of the camera's baseplate.

Step 4: Upload Code to the Arduino Pro Mini Board - Here, the researchers wrote the code required to control the motor's movement and upload it to the Arduino Pro Mini board. This code sends signals to the motor driver to move the camera's baseplate in a particular direction and at a specific speed.

Step 5: Connect the Camera Mount - In this step, affix the camera mount to the gantry plate, which maintains the camera's stability and synchronizes its movement within the rail. It is also the designated location for mounting the camera holder where the cameras can be mounted.

Step 6: Build the Mobile Application Interface - This step involves creating a mobile application interface for controlling the device's movement. In this step, the researchers designed a user-friendly interface that allows users to input the direction and speed of the device's movement.

Step 7: Connect the Sight guide to the Mobile Application - In this step, you will establish the connection between the ESP32 Camera and the Mobile Application. The live feed seen from the mobile app will serve as the guide for the input camera's sight.

Step 8: Connect the Mobile Application to the Arduino Pro Mini Board - In this step, establish the connection between the created mobile application and the Arduino Pro Mini board via Wi-Fi module. This enables the mobile application to communicate with the board and control the movement of the device.

Step 9: Develop the Mobile Application Control System – In this step, the researchers created a mobile application that sends signals to the Arduino Pro Mini board to control the movement of the device. The control system should have features such as button movement control, and preset control.

Step 10: Test the System - This step involves testing the mobile application-controlled device to ensure that it works correctly. Check for any errors or glitches in the system and make necessary adjustments.

Step 11: Make Improvements - Based on the test results, make improvements to the system. This may include modifying the mechanical components, adjusting the code, or enhancing the mobile application interface.

Block Diagram

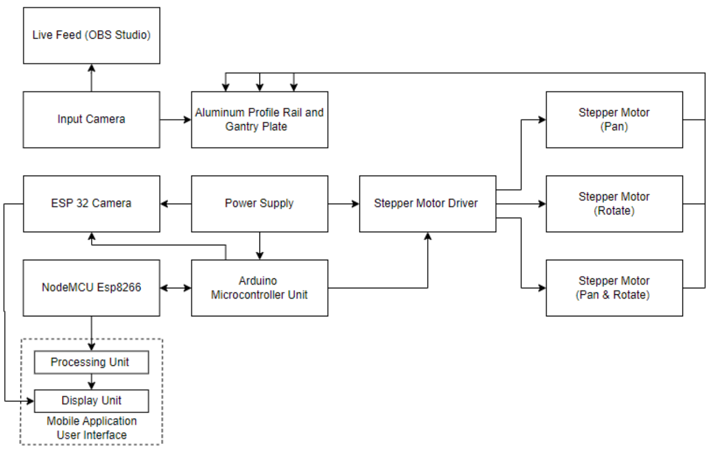

Figure 2.2: Block Diagram

The diagram above represents different electronic components and how their connectivity yields the development of the proposed prototype. In figure 3.3, the Arduino Microcontroller Unit serves as the brain and core of the system, this electronic device receives and processes inputs coming from other electronic components. The microcontroller also sends data output which was used in controlling different output components that includes IoT/WIFI Module and stepper motor. It also provides the display output of the ESP32 Camera.

The block diagram illustrates that the Wi-Fi module receives commands from the Mobile application and transmits them to the microcontroller. The microcontroller, in turn, operates the stepper motors via the motor driver, causing the camera mount to move along the linear guide rail and slider carriage.

The camera mount is mounted to the gantry plate of the CAMTRACK, which is affixed to the base of the device. It includes the linear guide rail connected to the gantry plate for managing its motion. The input camera can be attached to the gantry plate directly or via the camera holder. The power supply supplies power to the system, powering the stepper motors and other electronic parts.

System Operation of CAMTRACK

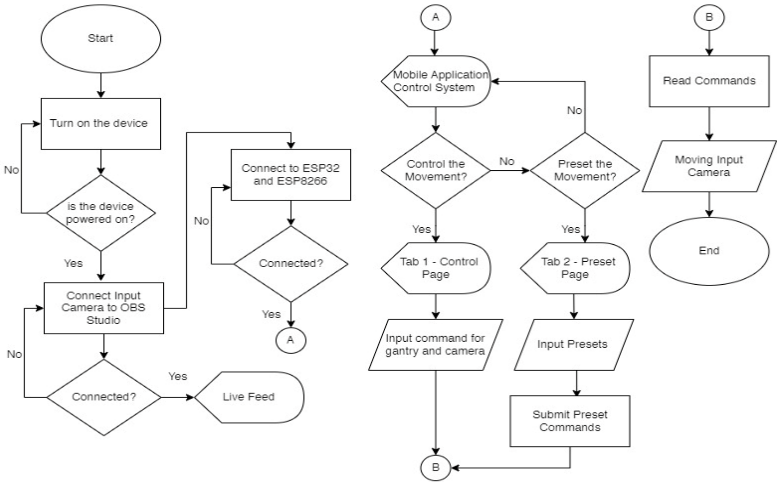

Figure 2.3: System Operation of CAMTRACK

The developed prototype begins with powering the device on. The next step is to connect the input camera to the OBS Studio to have a live camera feed on what the input camera sees. Then, establish its connection to the internet and camera using the ESP8266 and ESP32. Once the device successfully connects to the internet it then waits for a command to be received. Users have the option to control the movement of the input camera device based on their preference. The device would then check if there was a command giving instructions to move the motors based on the direction sent by the microcontroller from the mobile application.

CAMTRACK Hardware Design

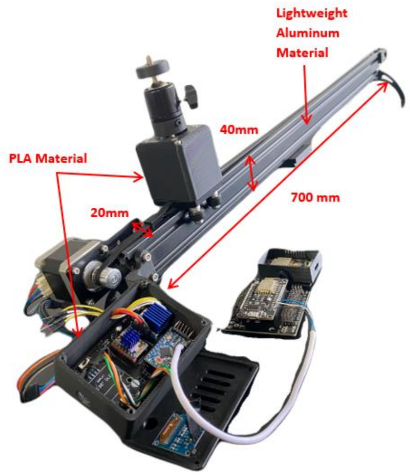

Figure 2.4: CAMTRACK Hardware Design

The design featured in Figure 3.5 shows the initial design of the prototype. The CAMTRACK device has a length of 700mm. the rail of the prototype has the dimension of 20x40mm and is made of aluminum profile due to its soft and lightweight characteristics. The rail is designed with a smooth V-groove shape to facilitate smooth linear motion. The prototype is built up using various components that interconnect with each other for the prototype's features. The 3d printed part for the enclosure is made up of PLA which is a thermoplastic monomer from organic sources such as corn starch or sugar cane.

Mobile Application

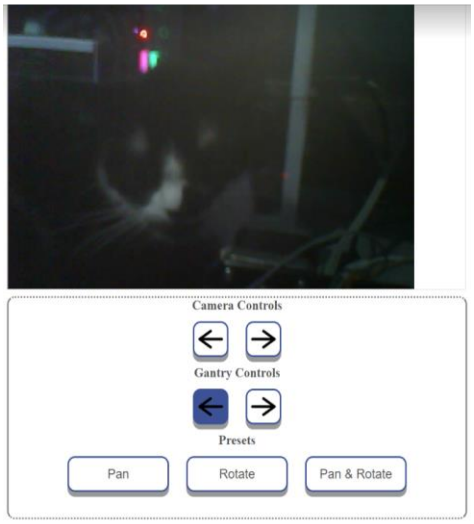

Figure 2.5: Mobile Application User Interface

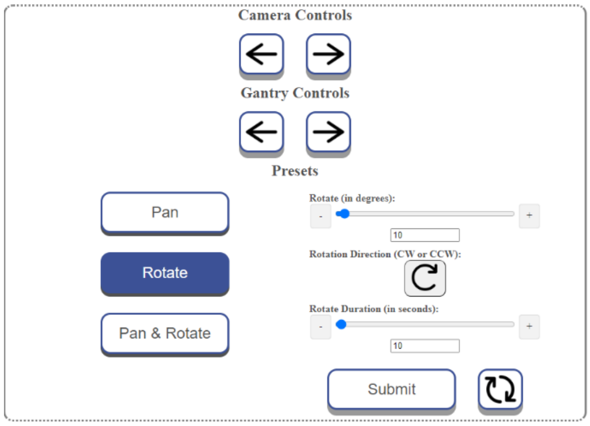

Figure 2.6: Camera Movement Presets

The mobile application typically provides a user-friendly interface for controlling the device. It allows the user to adjust settings such as the speed and distance of movement, as well as the direction of the device's movement. This includes left-to-right and rotational motion and vice versa.

One of the key features of the mobile application is that it allows the user to see what the camera is capturing using the ESP32 Camera. The live camera feed enables the user to make adjustments to the device’s slider movement and positioning as necessary to achieve the desired shot.

Overall, the mobile application provides the user with a convenient and intuitive way to control the device, customize the camera's movements, and view the camera feed to ensure the desired shot is achieved.

Wiring Diagram

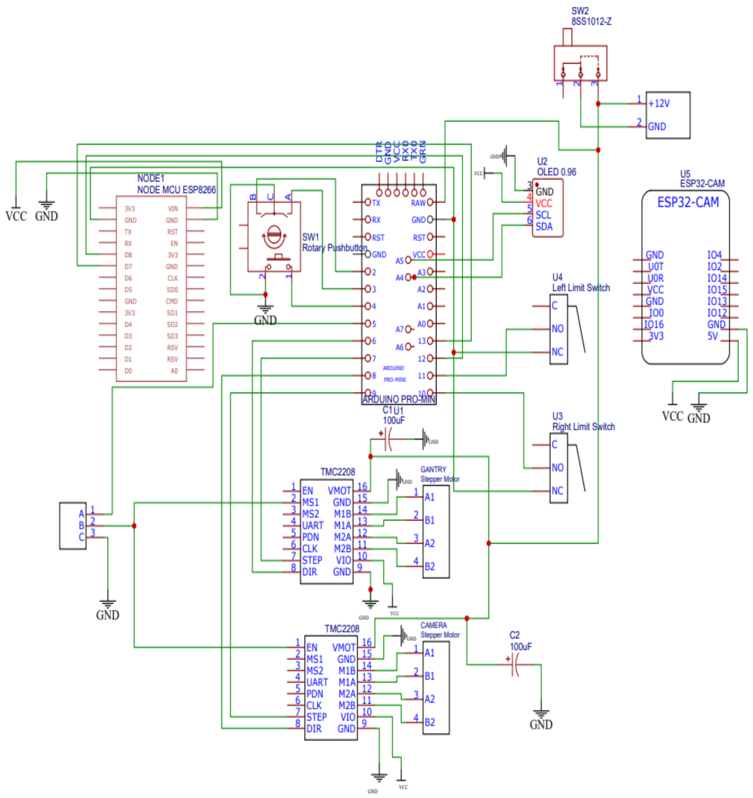

Figure 2.7: Wiring Diagram

D. Data Analysis and Procedure

The study utilized a grading system type of survey questionnaire for the validation of the prototype. The data and information gathered from the respondents allows the proponents to identify the system's bugs, errors, and improvements to be done. The validation results are then examined with respect to the measurement tools and techniques, to achieve a quantitative result that supports the significance of the prototype. The questionnaires utilized are specifically designed to capture the probability ranges by assigning equivalent interpretations and mean score ratings to the responses, with the scores then averaged to provide an overall assessment (Doctor, A. C., & Benito, C. H. 2019).

TABLE 1: LIKERT SCALE

Scale	Verbal Interpretation	Mean Rating Score
4	Strongly Agree	3.26 – 4.00
3	Agree	2.51 – 3.25
2	Disagree	1.76 – 2.50
1	Strongly Disagree	1.00 to 1.75

III. RESULTS AND DISCUSSIONS

The researchers performed a sequence of tests to verify the prototype's ability to perform the desired task. This process assisted the researchers in identifying potential malfunctions or flaws in the device's functions.

Results of Evaluation

The sampling technique used for the study is stratified random sampling, where random sampling is conducted to the divided population or subgroups based on certain characteristics to minimize sampling bias and enhance generalizability. In this section, a group of 25 participants were engaged in assessing the prototype, which was proven to be enough to create a reliable foundation for solid evaluation results (Graglia 2022). Specifically, it includes 22 content creators in social media, 2 photographers, and 1 videographer. The proponents formulated questions that align with specific ISO 25010 criteria. Prior to completing the questionnaires, the participants were given a brief introduction to all the prototype's functions through a live demonstration. Additionally, it gives the participants the opportunity to personally test the various features of the prototype.

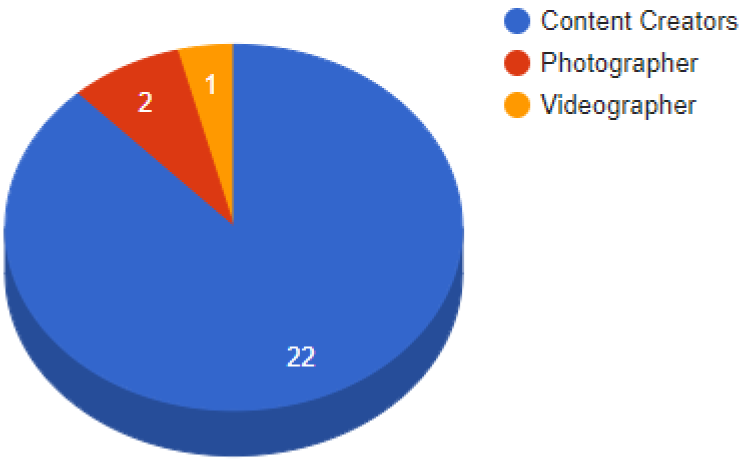

Figure 3.1 Population of the Participants

Functional Suitability Evaluation

The evaluation for functional suitability is to discover if the device and its associated mobile application works together seamlessly, allowing users to control the device with ease. The statements for this evaluation

The statements provided in this evaluation pertain to the sub-characteristics of functional suitability, specifically functional completeness, functional correctness, and functional appropriateness. They address the device's ability to fulfil its intended functions comprehensively, accurately, and appropriately. (ISO 25000, 2022)

Table 3.1: Functional Suitability

FUNCTIONAL SUITABILITY EVALUATION				
Constructed Statements based on the sub-characteristics of Functional Suitability	Mean	N	SD	Verbal Interpretation
FS1: The CAMTRACK can assist the user in capturing photos and videos.	4.0000	25	0.00000	Strongly Agree
FS2: The camera mount is designed to be compatible with different cameras.	3.7600	25	0.43589	Strongly Agree
FS3: The mobile app has features for controlling the device, such as travel distance and time.	3.8800	25	0.33166	Strongly Agree
FS4: The mobile app controls the CAMTRACK's movements without any unexpected behaviour.	3.2400	25	0.72342	Agree
GRAND MEAN: 3.7160 = HIGHLY FUNCTIONAL				
LEGENDS: *N – Population* *SD – Standard Deviation* *GM – Grand Mean* *FS(n) – Functional Suitability*				VERBAL INTERPRETATION: *3.26 – 4.00 = Strongly Agree* *2.51 – 3.25 = Agree* *1.76 – 2.50 = Disagree* *1.00 to 1.75 = Strongly Disagree*

The evaluation scores based on the functional suitability of the prototype are presented in Table 3.1. The means of each question were averaged, resulting in a grand mean of 3.7160 that indicates a "Strongly Agree" response which means that the prototype is highly functional and is highly suitable for multimedia content creation.

Performance Efficiency Evaluation

The evaluation for performance efficiency provides the data if the device moves smoothly and accurately, with no lags or delays. The mobile application should respond quickly to user inputs, with minimal loading times.

The statements in this evaluation fall within the sub-characteristics of performance efficiency, specifically addressing aspects such as time behaviour and capacity. These statements assess the device's ability to perform tasks efficiently within acceptable timeframes and handle the expected workload effectively. (ISO 25000, 2022)

Table 3.2: Performance Efficiency

PERFORMANCE EFFICIENCY EVALUATION				
Constructed Statements based on the sub-characteristics of Performance Efficiency	Mean	N	SD	Verbal Interpretation
PE1: The CAMTRACK quickly responds to user inputs for controlling the device's movement.	3.2000	25	0.57735	Agree
PE2: The mobile app provides smooth motion control without delays or lag.	3.1600	25	0.55377	Agree
PE3: No performance issues are observed during the operation of the prototype.	3.2400	25	0.59722	Agree
PE4: The CAMTRACK can handle a variety of camera weights and sizes without affecting its performance.	3.4000	25	0.50000	Strongly Agree
PE5: When using CAMTRACK, the image output of the attached camera is not blurry/shaky.	3.8400	25	0.37417	Strongly Agree

GRAND MEAN: 3.3680 = HIGHLY EFFICIENT	
LEGENDS: *N – Population* *SD – Standard Deviation* *GM – Grand Mean* *PE(n) – Performance Efficiency*	VERBAL INTERPRETATION: *3.26 – 4.00 = Strongly Agree* *2.51 – 3.25 = Agree* *1.76 – 2.50 = Disagree* *1.00 to 1.75 = Strongly Disagree*

Presented on Table 3.2 are the evaluation scores based on the performance efficiency of the prototype. The performance efficiency evaluation achieved a grand mean of 3.3680 which means that the respondents strongly agreed that the prototype's performance is still highly efficient even when issues occur when making multimedia content.

Usability Evaluation

The evaluation for usability allows the proponents to find out if CAMTRACK is user-friendly. The device should be easy to set up and use, with a simple and straightforward interface.

The statements in this evaluation are related to the sub-characteristics of usability, specifically addressing learnability and operability. These statements assess the device's ease of use, including how easily users can learn to interact with it and operate its functionalities efficiently. (ISO 25000, 2022)

Table 3.3: Usability

USABILITY EVALUATION				
Constructed Statements based on the sub-characteristics of Usability	Mean	N	SD	Verbal Interpretation
U1: The controls and functions of the CAMTRACK is easy to understand.	3.8000	25	0.40825	Strongly Agree
U2: The terminology/words used within the mobile application is familiar to the user.	3.4000	25	0.50000	Strongly Agree
U3: Users can quickly grasp the basic functionalities of the CAMTRACK.	3.5200	25	0.50990	Strongly Agree
U4: The controls within the CAMTRACK are designed to be easy to use.	3.9600	25	0.20000	Strongly Agree
U5: Users can easily switch between different camera mounts.	3.8800	25	0.33166	Strongly Agree
GRAND MEAN: 3.7120 = HIGHLY USABLE				
LEGENDS: *N – Population* *SD – Standard Deviation* *GM – Grand Mean* *U(n) -Usability*				VERBAL INTERPRETATION: *3.26 – 4.00 = Strongly Agree* *2.51 – 3.25 = Agree* *1.76 – 2.50 = Disagree* *1.00 to 1.75 = Strongly Disagree*

Table 3.3 displays the evaluation score for usability where the means of the questions are averaged and resulted in a grand mean of 3.7120. Observing these results, the respondents strongly agree that the prototype is highly usable for its purpose. It also indicates that the prototype is easy to operate and easy to learn for multimedia content creation.

Maintainability Evaluation

This evaluation refers to the ability of the device to be modified effectively and efficiently without introducing defects or degrading its quality. It is a critical aspect to ensure that the system can be easily modified, updated, and repaired as needed.

The statements in this evaluation are focused on the sub-characteristics of maintainability, specifically testability and modifiability. These statements assess the device's ease of testing, including the ability to verify its functionalities and performance. Additionally, they evaluate the device's flexibility in terms of making modifications or updates to its design, features, or components. (ISO 25000, 2022)

Table 3.4: Maintainability

MAINTAINABILITY EVALUATION				
Constructed Statements based on the sub-characteristics of Maintainability	Mean	N	SD	Verbal Interpretation
M1: It is easy to replace or repair parts of the CAMTRACK if necessary.	3.5200	25	0.50990	Strongly Agree
M2: The CAMTRACK has a durable and long-lasting design that requires minimal maintenance.	3.6800	25	0.47610	Strongly Agree
M3: The CAMTRACK can be upgraded or modified for future improvements.	3.9200	25	0.27689	Strongly Agree
M4: The camera mount supports accommodation of different camera models.	3.4400	25	0.76811	Strongly Agree
GRAND MEAN: 3.6400 =HIGHLY MAINTAINABLE				
LEGENDS: N – Population SD – Standard Deviation GM – Grand Mean M(n) -Maintainability				VERBAL INTERPRETATION: *3.26 – 4.00 = Strongly Agree* *2.51 – 3.25 = Agree* *1.76 – 2.50 = Disagree*

Table 3.4 displays the evaluation scores for the maintainability criteria. It obtained a grand mean of 3.6400, indicating that the prototype created is highly maintainable. The respondents strongly agree that the prototype is both maintainable and modifiable. This suggests that the prototype possesses the qualities necessary for easy maintenance and modification.

Reliability Evaluation

The evaluation for reliability is done to find out if the device operates consistently and without errors or malfunctions. Furthermore, the mobile application should be stable and not crash or freeze during use.

The statements in this evaluation pertain to the sub-characteristics of reliability, specifically focusing on fault tolerance and recoverability. These statements assess the device's ability to operate consistently and reliably, demonstrating its resilience in handling faults and its capacity to recover from potential disruptions or failures. (ISO 25000, 2022)

Table 3.5: Reliability

RELIABILITY EVALUATION				
Constructed Statements based on the sub-characteristics of Reliability	Mean	N	SD	Verbal Interpretation
R1: The CAMTRACK has a fast recovery capability to restore normal operation in case of disruptions.	3.6400	25	0.48990	Strongly Agree
R2: The CAMTRACK operates consistently and without any errors or malfunctions.	3.2400	25	0.59722	Agree
R3: The CAMTRACK had a low rate of failure or breakdowns.	3.1200	25	0.43970	Agree
GRAND MEAN: 3.3333 = HIGHLY RELIABLE				
LEGENDS: *N – Population* *SD – Standard Deviation* *GM – Grand Mean* *R(n) - Reliability*				VERBAL INTERPRETATION: *3.26 – 4.00 = Strongly Agree* *2.51 – 3.25 = Agree* *1.76 – 2.50 = Disagree* *1.00 to 1.75 = Strongly Disagree*

Presented on Table 3.5 are the evaluation scores for the reliability evaluation of the prototype. It achieved a grand mean of 3.3333 which indicates that the respondents strongly agree that the prototype is highly reliable when making content in multimedia.

IV. CONCLUSION

CAMTRACK represents a significant development in the world of multimedia content creation. Through meticulous development and evaluation, this advanced device has transformed camera movements, opening possibilities for photographers, videographers, and content creators to enhance their creative projects and craft compelling visual narratives. To accomplish the study, the researchers utilized an Arduino Pro Mini Microcontroller as the central control unit of the device. The rail system was constructed using a 20x40mm V-slot Aluminum Profile, while NEMA 17 Stepper Motors were employed for smooth and precise movement. Various components were integrated for seamless connections. The mobile application was developed using HTML, while the code for controlling the movements was programmed using the Arduino IDE. Thorough testing and evaluation were conducted to assess the prototype's functions and capabilities. The results confirm that the prototype operates as intended, delivering the desired output set forth in this study. It successfully performed its specified functions accordingly. Based on the testing and evaluation conducted, the proponents can confidently conclude that the prototype has the potential to assist multimedia users in capturing photos and videos. The image output quality produced by the device is deemed satisfactory, meeting the expectations set in this study. Overall, the comprehensive testing and evaluation conducted on the CAMTRACK prototype provide strong evidence to support the conclusion that it is a valuable tool for multimedia users, offering enhanced capabilities for capturing multimedia content.

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