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Two Degree-of-Freedom Camera Support System

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Abstract- A surveillance camera is used to observer and record the surroundings. There are many types of existing surveillance camera and each of them has their own specifications made to suit their respective purposes. For example, there are fixed, 1-degree-of- freedom (DOF) and2-DOF cameras. As for a moving camera, it is essential for it to be able to move freely so that it can capture the target object in awider range. The camera also should be able to be controlled wirelessly to give a better practicality to the user. Based on the specifications, this project is constructed to overcome these problems. A 2-DOF camera support system is to be created which can be controlled wirelessly via Bluetooth. The support will e made with two motors that can pan and tilt the camera. The user will need to download an application which has o screen control into their gadgets and this can be connected to the Arduino which controls the motors. The Arduino will process the command from the user and will move the right motor to execute the command. This project will help the user to control the surveillance camera from a distance wirelessly and have at least a 360° pan view and 90° tilt view.

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Strictly as per the compliance and regulations of:

Two Degree-of-Freedom Camera Support System

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Chapter 1

I. Introduction

a) Background Studies

Surveillance brings the meaning of the observation of the actions, behavior, or other changing information, typically of individuals to influence, direct, manage or protect them. By using a surveillance camera, the surroundings can be observed, recorded and re- watched for future references.

There are many types of surveillance camera available in the market. Each of them is made to serve different purposes. For example, a bullet surveillance camera is usually placed indoors and it is mounted on the wall. The view is fixed and it is uncontrollable. Besides that, There are widely used for wide-area surveillance environment. Some of them are already programmed to move on their own, and there are ones which are controllable by the user.

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Usually the security cameras are controlled using the control panel from the control room. This project will ease the user as it will be interfaced with the Android application so the user can control it without having to bring a remote control.

b) Problem Statement

A moving camera support will offer many advantages compared to a static one. It will allow the user to point a surveillance camera to the target object better. Another potential usage will also be an automatic tracking of a moving object. To achieve this, a 2-DOF camera support is required and will be designed and implement ted. The camera support should be controllable wirelessly to improve its usefulness for the users.

c) Research Objectives

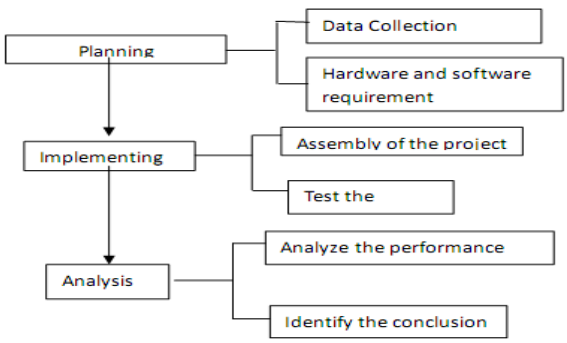
The purpose of this project is to design a 2-DOF support that can hold a video camera. The movement of the support is expected to be controlled via a wirelees communication, from and android device.

The core objectives of this project are:

1. To design a 2-degree-of-freedom camera support (Yaw and Pitch)
2. To design the controllers.
3. To design the wireless communication hardware and software.
4. To implement and test the design.

d) Research Methodology

Methodology is the theoretical arguments that researchers use to vindicate their research methods and project. Research methodology is the procedure of conducting research in order to achieve the aim of the project. These are the methodologies that have been lain out for this project. There are three parts for the process, which is planning, implementing and analysis.



For planning the first one is the data collection or literature review. A study of past projects that can help with the understanding of the research is done. From these studies, new ideas can be implemented to the project with references from existing ones. For this part, the different types and designs for the mount has been studied. Next is to select the components that are most suitable to be used in the project. The components are chosen based on their materials and the calculations made. For the software requirements, a couple of softwares are compared and most suitable is to be implemented.

After that, the hardware and software parts are integrated and the project is tested. Based on the data collected from the test, the performance of the project will be further analyzed to improve it until all the objectives are achieved. Fanally, the conclusion of the project is to be identified and a complete paperwork is prepared.

Chapter 2

II. Literature Review

a) Introduction

The aim of this project is to construct a 2 degree of freedom camera support system that can pan 360° and tilt 9°. This system is to be controlled from an Android application in the phone via Bluetooth. With this, the surveillance camera can be controlled wirelessly and ease the user.

b) Fixed surveillance Camera[1]

A fixed surveillance camera only points to one direction, which makes them very suitable for monitoring very specific area of interest. Besides that, they are used when it is beneficial to install them in clearly visible locations. Therefore, fixed surveillance cameras are quite effective not only to capture footages of suspicious activity, but also for deterring criminals and vandal from doing their acts to begin with. The direction of the camera is set during the installation phase. To cater to a wide variety of surveillance needs, they commonly accept interchangeable lenses and housings.

c) Two-stage Motor-on-Motor (MOM) Design[2]

In this design, the first motor will be placed at the bottom of the support so it can turn the mechanism through one degree of freedom, that is pan or yaw direction. Then the other motor is placed on top of the first motor and moves the mechanism in the pitch or tilt direction. It must be powerful enough to move the camera. Due to the placement of the motors in this design, the first motor is usually more powerful than the second one. It is because it needs to support the weight of the second motor together with the camera.

d) Parallel Linkage Design [3]

Two linear stepper motors are used in this design. It is also called a Platform Pantilt. The platform is moved by lowering and raising two shafts attached to linear stepper motors that, along with a third fixed shaft, are attached to the platform. Single and double universal joints are used to be attached to the to the shafts. This design is quite alike to the six-degree-of – freedom Steward plat form. This design is good in a way, but it has a limited precision and because it uses stepper motors, it is hard to construct this device in a small scale.

e) Motor [4]

A brushless DC motor runs from a DC power source but it does not have commutators and brushes. A brushless DC motor is more efficient, reliable, have low electrical noise and good speed control as compared to a brushed DC motor. While the key advantage to it is it has no brushed or commutaotr to wear out producing a much higher speed and lower maintenance.

On the other hand, a stepper motor does not rotate continuously like a conventional DC motor but it moves according to its step angle, with the angle of each rotational movement or step relies to the number of stator poles and rotor teeth that the stepper motor has.

For this project, the brushless DC motor is believed to be the best motor to be used.

f) Bluetooth

Bluetooth is wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz[4] from fixed and mobile devices, and building personal area networks (PANs). It was invented by Ericsson in 1994 and was regarded as a wireless substitute to RS-232 data cables. It can be connected to a number of devices, overcoming problems of synchronization.

Bluetooth is a standard wire–replacement communications protocol primary designed for low-power consumption, with a short range based on low-cost transceiver microchips in each device. To connect to Bluetooth, the devices do not have to be in visual line of sight of each other as it uses a radio communication system. But then, a quasi-optical wireless path must be viable. The effective range of Bluetooth is affected by the propagation conditions, material coverage, battery conditions variations, production sample and antenna configurations. The Bluetooth Core Specification mandates a range of not less than 10 meters, but there is no upper bound on actual range. Manufacturer's implementations can be tuned to provide the range needed for each case.

g) Wireless Local Area Network

A wireless local network (WLAN) is a wireless computer network that connects devices by a wireless distribution method within a bounded area. This allows the user to move around within the area without being disconnected to the network.

A peer-to-peer network permits the wireless devices to directly communicate with one another. They can discover and communicate directly without involving a central access point as long as they are within each other's range. This method is usually used by two devices so they can connect to each other from a network. This can only happen to devices that are in close proximity.

h) Android [5]

Android is a mobile operating system (OS) based on the Linux Kernel and currently developed by Google. With a user interface based on direct manipulation, Android is designed primarily for touch screen mobile devices such as smart phones and tablet computers, with specialized user interfaces for televisions (Android T), cars (Android Auto), and wrist watches (Android Wear). The OS uses touch inputs that loosely correspond to real-world actions, like swiping, tapping, pinching, and reverse pinching to manipulate on-screen objects, and a virtual keyboard. Despite being primarily designed for touch screen input, it has also been used in game consoles, digital cameras, regular PCs and other electronics.

Chapter 3

III. System Analysis and Methodology

a) Introduction

This chapter will discuss the integrated system of the surveillance camera support system and also the ways to implement them. This project can be breakdown into two parts, which is the hardware part and software part.

b) Project Overview

The system is divided into hardware design and software design. The hardware design has 3 further breakdowns which are electrical design, mechanical design and bill of materials. The materials and hardware are decided upon after comparing with different options and the most suitable is selected so that the project will work at optimum performance.

Figure 3.1 shows the overall flow of the system. The inputs come from the android device and then through the Bluetooth module, the signals is delivered to the Ardui no for further processing. Next, the Arduino sends signals to respective motors for them to move according to the input from the user.

c) Electrical Design

The systems electrical design and component selections will be further discussed.

d) Component Selection

From the literature review, these components is deemed the most suitable to be used in this project for it to be working successfully. There are few factors that came into consideration for the components to be chosen such as size, durability, maintenance and price.

No	Name of omponents	Quantity
1.	Arduino UNO	1
2.	20 rpm Motor	1
3.	30 rpm Motor	1
4.	Arduino Motor Shield	1
5.	Bluetooth Module	1

e) Arduino UNO

The Arduino Uno is a microcontroller board on the A Tmega 328 (datasheet). It is consist of 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a power jack, a USB connection, an ICSP header and a reset button. It has everything required to support the microcontroller; just connect it to a computer with a USB cable or power it with an AC-to-AC adapter or battery to get started. The Uno is different from all previous boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmegal16U2(Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Microcontroller	ATmega328
Operating Voltage	5V
Input voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Analog Input Pins	6
DC Current per I/O Pin	40mA
DC Currentfor 3.3 V Pin	50mA
Digital I/O Pin	14 (of which 6 provide PWM output)
Flash Memory	32KB (ATmega328) of which 0.5 KB used by boot-loader
SRAM	2KB (ATmega328)
EEPROM	1KB (ATmega328)

Calculations of the torque have been made prior to the selections of the DC motors.

Let the mass of the camera= 3N, width =0.021m, height= 0.05m

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Based on the torques calculated, the 20 rpm motor is selected as it can handle the motor torque calculated.

These are the specifications of the motor:

Operating Range: 3-12VDC Output Power: 1.1Watt

Torque@Max Efficiency: 0.27N.m (12V)

Torque @ stall: 1.306N.m.@12VDC

Stall current: 0.5A @ 12VDC

(6mm) Diameter Shaft

No load current: 45mA
No load current@ Max Efficiency: 95mA (12V)
No load speed: 20 RPM
No load speed @ Max Efficiency: 15.9 RPM
Gear ratio: 150:1
Motor size:1.30" Dia. x 1.015"L
Gear size: 1.45"Dia. x .985"L
Shaft size: 6mm (0.236") Dia. x 0.715"L
Weight: 0.2813 1bs. (4.5 oz)

f) Motor Driver

Logic Control Voltage: 5V (From Arduino)
Motor Driven Voltage: 6.5~12v (VIN Power Supply), 4.8~35V (External Power Source)
2 way motor drive
Logic supply current Iss: ≤36mA
Motor Driven current Io: ≤2A
Maximum power consumption: 25W (T=75°C)
Up to 2A current each way
Pin 4, 5,6,7 are used to drive two DC motor
Support PWM speed control
Support PLL advance speed control
Size: 55x55mm

g) Bluetooth Module

Supply voltage: 3-3V DC
Transmitter output power: 18dBm
Receiver sensitivity: -86dBm
Mounting: SMD
Standard: 2.0 EDR
Bluetooth class: 1
Operating temperature: -40…85°C
Dimensions: 28.2 x 15 x 2.8mm Interface:
PCM
UART
USB
Additional information
Gross weight: 3.88 g
Collective package [pcs]: 400

h) Mechanical Design

The mechanical design is modeled with Solid works software. The drawings are attached in the appendices.

i) Bills of Materials (BOM)

The total cost of the development of the surveillance camera support system is as below:

Table 3.3 : Bills of Materials

Parts	Quantity	Price (RM)
Arduino	1	117.00
20 rpm DC Gear Motor	2	90.00
Motor Shield	1	43.00
Bluetooth Module	1	42.00
1000mmx60mmx30mm Mild Steel Plate	1	25.00
Gear	2	20.00
TOTAL COST		RM 427.00

Chapter 4

IV. Conclusion

a) Achievement of objectives

Overall most of them objectives for this FYP 1 have been achieved. The 2-DOF camera support system has been designed. The final mechanical and electrical components have been selected from various selections based on the calculations results, suitability and cost. The wireless connection is decided to be via Bluetooth connected to the Android device. The support system is expected to move smoothly and comply with the specifications set.

b) Limitation and challenges

The limitation of this project is to make the size smaller. It is because the components involved are quite big in size. The design that has been decided is the smallest one while taking into account the costs involved.

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