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Fabrication of a Long Distance Controlled Pan-Tilt Mechanism for Camera

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ABSTRACT: This project is about fabricating a pan-tilt mechanism capable of being controlled from a long distance that can be connected and controlled through cell phones. This simplest and obvious robotic model is based on the motor on motor (MOM) design by using two identical stepper motors to cover the whole area view operated manually from long distance with Dual Tone Multi Frequency system (DTMF) signaling. The lower (pan) stepper motor have to be powerful enough to move the two brackets, DTMF receiver with its holder and the upper (tilt) stepper motor have to move most upper bracket, DTMF receiver with its holder only. We would like a pan-tilt mechanism to be accurate, slow, small, low-powered and inexpensive. The technology is used in many different consumer-based services including ATM booth monitoring; Surveillance based applications; Household security; Car Parking etc.

Keywords: Mechatronics, Pan-Tilt Mechanism, Remote Monitoring, Cost Effective, Security Purpose

1. Introduction:

Pan-Tilt mechanisms have been a source of inspiration and frustration to computer vision researchers. The source of inspiration is nature, where humans rely on their pan-tilt apparatus to achieve a wide field of view visual sensing [1]. The alternative to mechanical pan-tilt mechanism is electronic scanning i.e. software pan-tilt mechanism are more convenient and reliable than their motorized counterparts but we argue that they will be ultimately more expensive [2]. The source of frustration with pan-tilt devices is acquiring or building, then calibrating and controlling, the mechanism itself. Low speed inexpensive motorized pan-tilt platforms are available for example from Edmund Scientific, but these have no computer controls. Raviv used a Cartesian manipulator to implement camera pan, tilt, roll and translation [3]. The whole mechanism is driven by high efficient Stepper motor one of which is directly coupled with base of the platform which controls the pan movement and another Stepper motor is coupled to the joining point of the first and second bracket. Camera allocation system is built upon the top of the upper bracket, so it can act as an eye for the robot. By using this appropriate perception equipment, the GSM-based robot can localize itself and capture surrounding. The arrangement is such in a way that the camera can monitor the surrounding with the movement pan 340 degrees and tilt 45 degrees of the mechanism. This robot is based on a control system using Dual Tone Multi-Frequency system (DTMF).

2. Methodology

2.1 Operation:

The pan-tilt platform's hardware system can be operated from any position without direct visual and auditory access to the hardware. 3G networks, short for third Generation, is the third generation of mobile telecommunications technology [4] which can be used to capture surroundings. Data and video originating from the camera during monitoring can be used to operate its movement when 3G will be available. According to the signal got from GSM module, the microcontroller operates the robotic platform. And the motor drive runs by the signal of a microcontroller. This robot is a wireless GSM-based system which can be operated from any corner of the world where networking system available by being in a fixed position. The success or failure of the mechanism highly restricted to factors such as camera's weight, structural weight, power input etc. It often tends to give vibration when kept in motion. This does not contain any special intelligence such as working in water or any dark place; highly dependent on the performance of a camera.

2.2 Pan-Tilt Platform Fabrication:

The main fabrication procedure is focused to keep the platform simple, small, fairy looked and easily portable so that reliability can be increased. A simple construction of the system is easy to implement. It is also helpful for having a good operational system. And small low weighted easily portable platform can be replaced and connected to the plug in any place. We have used power cable instead of battery in this system. The pan angle is set to 340 degrees to avoid interruption in movement due to wiring as the platform of the system is fixed in a place. We have tried to keep the system simple and so the tilting rotation angle is kept 45 degrees to safely hold a mobile phone in holder observing necessary wide view within the mentioned angle.

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2.2.1 Scopes and Applications:
1. A small (5×4×1.75) inches pan-tilt platform which is easily portable from one place to another and inexpensive has been designed and fabricated successfully.
2. A wide field of view can be obtained up to Pan Movement of 340 degrees and tilt movement of 45 degrees from the remote location.

2.2.2 Limitations:
1. The design is inefficient because it is not necessary to carry a motor on top of the other motor, can be constructed in another way.
2. The success or failure of the mechanism highly restricted to factors such as camera weight, structural weight, power output etc.
3. Often tend to be a lower speed and vibrate.
4. The mechanism is fixed in a place where a cable is connected and so have the view only which can be seen from that place.

2.2.3 Recommendations:
1. Servo motors may be used instead of stepper motors.
2. Another pinion of proper measurement and teeth may be attached with the lower (pan) stepper motor to extend stability in speed and smoothness for more reliability.
3. Another circuitry arrangement to display time with movement may be constructed.
4. The robotic mechanism may have a wireless power system and gear wheel system so that it can also be moved freely from one place to another.

2.3 Main Systems:
Architecting the system is a major requirement for functional analysis and fabrication process. System architecture gives the hierarchy of the system that helped to define deliverables for different subgroups. The GSM-based pan-tilt system is comprised of three main mechanical parts: Frame Structure System, the drive system and camera allocation system which are controlled using a control circuit through a GSM-based communication and DTMF technology. The system can be divided into several systems which are built separately. The following are the main components of the robotic system hardware:

1. Pan-Tilt System
2. Drive system
3. Camera allocation system
4. Power supply system

2.3.1 Pan-Tilt Mechanism:
The frame of the pan-tilt platform is made of Thai Aluminum based on pan tilt system. The (5×4×1.75) inches frame's base has a rectangular shape including two brackets of (3×2×1.5) inches on the top of it. One stepper motor is located inside the base at the joint of the base and first bracket, another stepper motor is held between the joint of two upper brackets, GSM receiver is carried on the top of all brackets inside a holder. We have constructed the simplest and most obvious model based on the motor on motor (MOM) design by using two identical stepper motors, to cover the whole area view and operate it manually from distance by using DTMF technology. The lower (pan) stepper motor turns the mechanism through a definite degree of freedom, usually pan, and the upper (tilt) stepper motor through another definite degree of freedom, usually tilt. Pan-Tilt Movement is shown in figure 2; 3. The lower (pan) stepper motor have to be powerful enough to move two upper brackets, DTMF tone receiver with its holder and the upper (tilt) stepper motor have to move the upper bracket, DTMF tone receiver with its holder only.

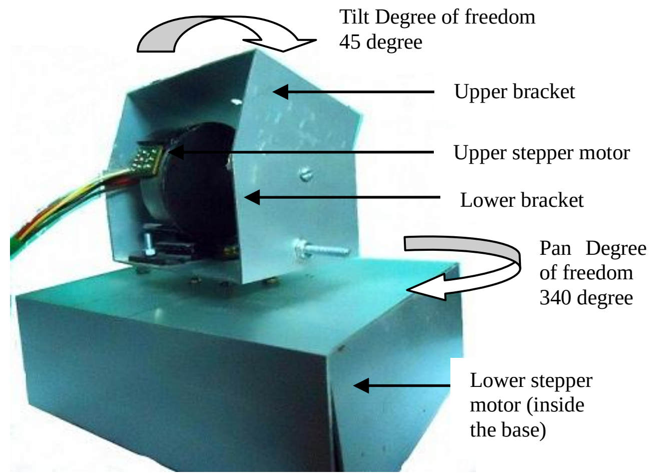

Fig. 1: Structure and Frame of Pan-Tilt System (side view)

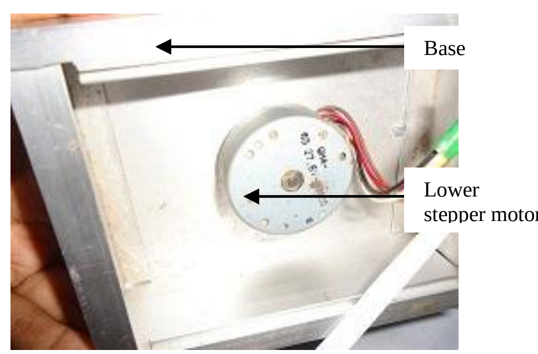

Fig. 2: Structure and Frame of Pan-Tilt System (bottom view)

2.3.2 Drive System:
Drive system may be subdivided into some groups to make the drive system understandable easily.

2.3.2.1 Motor Drive System:
The whole mechanism is driven by high efficient Stepper

motor one of which is directly coupled with the base of the platform which controls the pan movement and another stepper motor is coupled to the joining point of the first and second bracket. There is no differential speed mechanism in this robot but we can run this robot at pan 340 degrees and tilt 45 degrees by DTMF system from a long distance. We can easily move the robot in pan and tilt direction by controlling the motors.

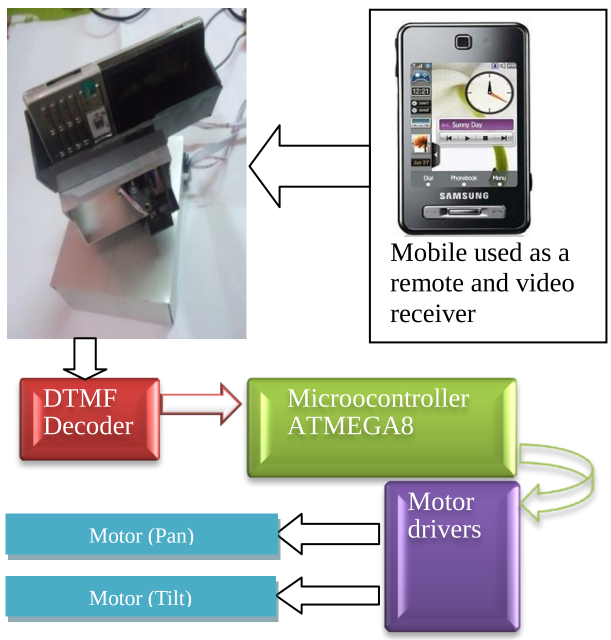

Fig. 3: Block diagram of Motor drive system

2.3.3 Camera Allocation System:

Camera allocation system is built upon the top of the upper bracket in the mechanism which is made of glass. The arrangement is such in a way that the camera can monitor the surrounding with the movement pan 340 degrees and tilt 45 degrees of the mechanism. The camera can be inclined maximum 45 degrees by the wish of an operator when it is needed to be controlled by two Stepper motor.

Fig. 4: Pan-tilt allocation system without camera

Fig. 5: Pan-tilt allocation system with camera

2.3.4 Power System:

The mechanism is supplied with voltage by putting the plug into a plug. When the circuit is closed 220 V will be supplied to the mechanism. The voltage is distributed among microcontroller and two stepper motors each of 6V. A step down transformer is used to reduce the amount of voltage in the required level. The capacity of a microcontroller to support is not more than 5 V and may damage also if the limit of voltage crosses. So a voltage regulator is used to assure that only the correct amount of voltage is inserted through the microcontroller.

2.4 Project Overview:

The mobile that makes a call to the mobile phone stacked in the pan-tilt mechanism acts as a remote. The signal generated by the DTMF encoder is the direct algebraic submission, in real time of the amplitudes of two sine’s (cosine) waves of different frequencies, i.e., pressing 5 will send a tone made by adding 1336 Hz and 770 Hz to the other end of the mobile [6] and mechanism will stop. The tones and assignments in our project with the DTMF system shown figure 7 below:

Frequencies	1209 Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	1	Forward	3	A
770 Hz	Left	Stop	Right	B
852 Hz	7	Backward	9	C
941 Hz	*	0	#	D

Fig. 6: Table of keypad frequencies [5]

3. Circuit Design

3.1 Circuit Design for Stepper Motor Driver:

Fig. 8 shows the circuit design for two stepper motor. In this project, two stepper motors are used. One (upper) stepper motor is for pan movement and other (lower) stepper motor is for tilt movement. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications [7]. They can be controlled by the manual switches or by DTMF input. When a switch is pressed it sends a signal to the microcontroller. This converted microcontroller output is then fed to the ULN2004 IC input. Finally, this IC controls the stepper motor connected with it with the corresponding signal. A LED diode is a Semiconductor diode that produces visible or infrared light when subjected to an electric current, as a result of electroluminescence [8] which indicates the proper power supply continuity when project circuit is closed. Four switches are used for controlling pan-tilt movement and another switch is stopping switch for both of the motors.

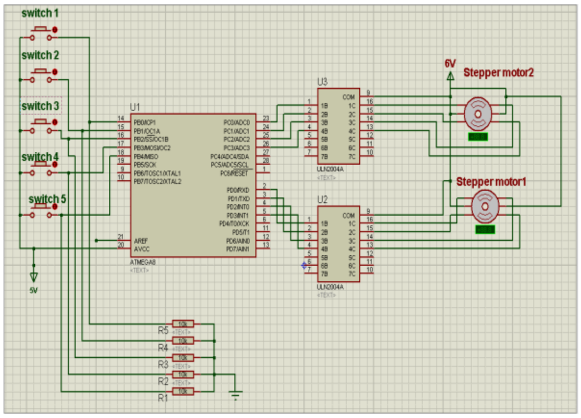

Fig. 7: Circuit design for motor controlling

3.2 Complete Experimental Setup:

Complete Experimental Setup is shown in fig. 7. For this experimental set up two cell phone is required one is to being used as a remote or video receiver and another is kept connected to the pan-tilt mechanism with a DTMF decoder circuit. In the course of a phone call if any dial of the keypad is pressed the command signal passes through a tone to the DTMF decoder circuit. The preprogrammed microcontroller circuit is commanded to pass the information to defined IC and drives motor in definite direction pan or tilt. This is how the motor drive system is activated. Video can be received from a remote location of pan-tilt platform when 3G will be available by keeping the cell phone connected with DTMF decoder circuit in the mobile carriage and positioning it at a suitable angle.

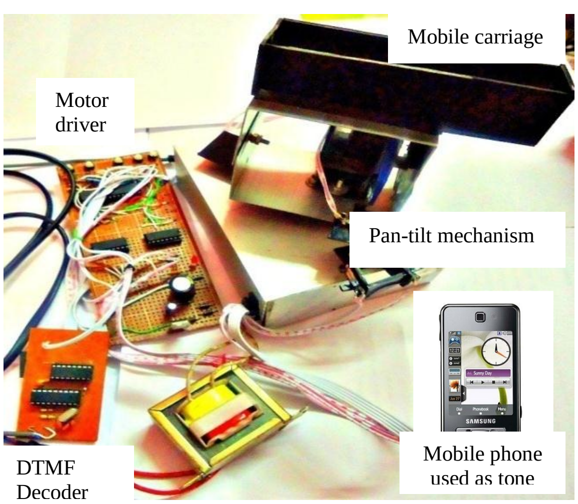

Fig. 8: Complete Experimental Setup

4. Performance Test and Results:

4.1 Performance Test of Pan-Tilt Mechanism:

As the project is successfully run, so it is a great achievement. We have counted down time with help of two stopwatches. One of which we had started with the pressing of a dial and other with the movement of the mechanism and they were stopped accordingly to the stoppage of the mechanism movement and stoppage of pressing time. So that we had been successful to have the response time after pressing a dial and stoppage of pressing dial. But no response time is found. All data's for pan movements and tilt movements are collected. Digital Angle Finder is used for angular measurement. We have recorded the timing for 3 times in each and every step of the movement and get the average values of the data so that we may get an approximately accurate value. A small delay in angle and time is got between the theoretical data and actual data as the mechanism takes some time during the movement due to vibration when power is on. In our project, for the pan-tilt movement of the brackets, we have chosen stepper motor. Because it is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor. But unavoidable jerk of stepper motor has caused response time delay; sometimes make the system slower or faster.

4.2 For Tilt Movement:

The minimum step angle for lower stepper motor is 1.875 degree. And it does not have any variation in angle and time for different steps with respect to theoretical time. For this reason, there belongs no angle and time difference in theoretical and experimental value. There is no response time needed to start this movement. The difference in data and graph is given below in graphed figure 9; 10 according to the data table-1; data table-2.

4.2.1 Graph for theoretical value and experimental value of angle with respect to step of tilt movement (Data table-1):

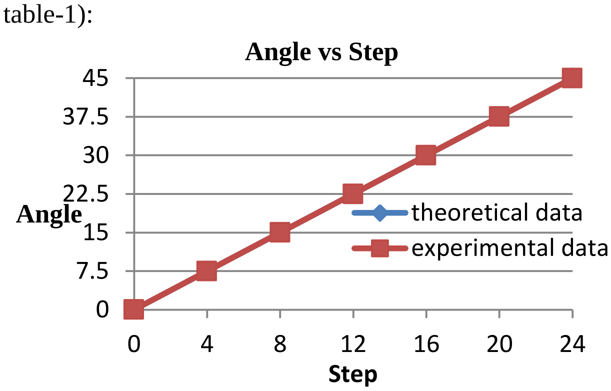

Fig. 9: Angle versus Step graph for pan movement

Data table-1: For theoretical value and experimental value of tilt angle with respect to step:

Step	Theoretical Angle	Experimental Angle
0	0	0
4	7.5	7.5
8	15	15
12	22.5	22.5
16	30	30
20	37.5	37.5
24	45	45

4.2.2 Graph for theoretical value and experimental value of time with respect to angle of tilt movement (Data Table-2)

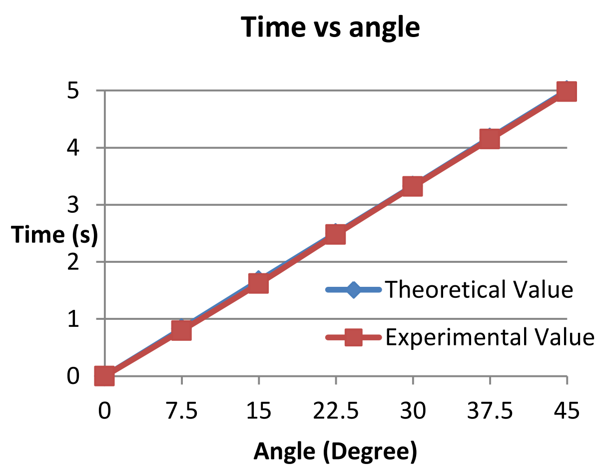

Fig. 10: Time versus angle graph for tilt movement

Data table-2: For theoretical value and experimental value of tilting time with respect to angle:

No. of steps	Angle (degree)	Theoretical value of time (s)	Practical value of time (s)	Deviation (%)
0	0	0	0	0
4	7.5	0.83	0.80	3
8	15	1.67	1.62	5
12	22.5	2.50	2.48	2
16	30	3.33	3.32	3
20	37.5	4.17	4.15	2

4.3 For Pan Movement:

The minimum step angle for lower stepper motor is 8.5 degree. But it takes some variation in angle and time for different steps with respect to theoretical time. For this reason there belongs an angle and time difference in theoretical and experimental value. There is no response time needed to start this movement. The difference in data's and graph is given below in the graphed fig. 11; 12 according to the data table-3 and data table-4.

4.3.1 Graph Figure for theoretical value and experimental value of angle with respect to step of pan movement (Data table 3):

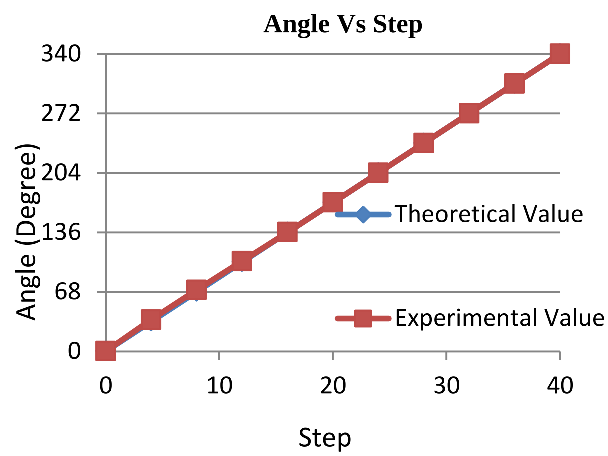

Fig. 11: Angle versus Step graph for pan movement

Data table-3: For theoretical value and experimental value of pan angle with respect to step:

Step	Theoretical Angle (Degree)	Experimental Angle (Degree)	Deviation (%)
0	0	0	0
4	34	36	2
8	68	70	2
12	102	103	1
16	136	137	0
20	170	170	0
24	204	204	0
28	238	238	0
32	272	272	0
36	306	306	0
40	340	340	0

4.3.2 Graph for theoretical value and experimental value of time with respect to angle of pan movement (Data table-4):

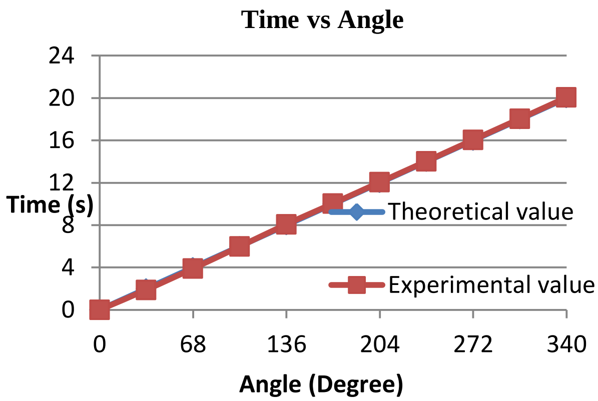

Fig. 12: Time versus Angle graph for pan movement

Data table-4: For theoretical value and experimental value of panning time with respect to angle:

No. of steps	Angle (degree)	Theoretical value of time (s)	Practical value of time (s)	Deviation (%)
0	0	0	0	0
4	34	2	1.89	11
8	68	4	3.90	10
12	102	6	5.98	2
16	136	8	8.08	8
20	170	10	10.05	5
24	204	12	12.05	5
28	238	14	14.04	4
32	272	16	16.05	5
36	306	18	18.05	5
40	340	20	20.06	6

4.4 Results:

The minimum step angle for tilt or vertical movement 1.875 degrees. Maximum possible angle for tilt or vertical movement 45 degrees. Difference in theoretical value and experimental value of tilt angle is 0 (shown in graph fig. 9). Difference in theoretical value and experimental value of tilting time is between ± 10 to 50 ms (shown in graph fig. 10). The minimum step angle for pan or horizontal movement 8.5 degrees. Maximum possible angle for pan or horizontal movement 340 degrees. Difference in theoretical value and experimental value of pan angle is between 1 to 2 degrees (shown in graph fig. 11). Time difference in theoretical value and experimental value of panning time is between ± 20 to 110 ms (shown in graph fig. 12). Due to unavoidable jerk of stepper motor there were ups and downs in angular and time reading. Only Theoretical and practical value of angle for tilting is found identical.

5. Conclusion:

The project is successfully constructed and executed. A small (5×4×1.75) inches pan-tilt platform which is easily portable from one place to another, slow and inexpensive has been designed and fabricated successfully. Approximately 120gm of weight can be controlled from a long distance by connecting two GSM mobile phones. The design is inefficient because it is not necessary to carry a motor on top of the other motor, can be constructed in another way. In addition, the success or failure of the mechanism is highly restricted to factors such as camera weight, structural weight, power output etc. and often tend to be a lower speed and vibrate. The mechanism is fixed in a place where the cable is connected and so have the view only which can be seen from that place.

6.Acknowledgement:

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