Time Delay Measurement in Unmanned Ground Vehicles

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Abstract—The paper presents a methodology to measure the time delay that takes place in sending and receiving of real time instructions between an Unmanned Ground Vehicle (UGV) and its controller called the Pilot System Unit (PSU). A PSU monitors every move of a UGV and charts its movements and operations based on the real time data it receives from the UGV. This time delay measurement represents essential information for the Collision Avoidance System (CAS) of the UGV as during real time scenario, a significant time delay could prove to be accidental for the vehicle. An electronic circuit recreating similar conditions as observed with a UGV was constructed and implemented to provide near accurate observations regarding the time delay that actually takes place. The results are observed in form of the time difference from the capturing of real time conditions by the UGV to the a arrival of the data at the PSU.

Index Terms— Collision Avoidance System, Pilot System Unit, Time Delay, Unmanned Ground Vehicle.

I. INTRODUCTION

An Unmanned Ground Vehicle (UGV) is a real size vehicle which is controlled by a Pilot System Unit (PSU) and directed to move in real time conditions according to its instructions. A UGV involves various kinds of systems for functioning, like Drive-Bysystem, Vision system, Collis i o n Av o i d a n c e System(CAS), Communication system, HVAC systems among others. Among these, the Vision System which contains cameras fitted in various places to account for a 180 degree field of view around the camera and the Collision Avoidance System which is responsible for interaction and implementation of PSU (also called controller) instructions come together for capturing of continuous images/ live streaming and sending it to the PSU for instructions. The process involves majorly two kinds of delay which could prove significant in real time conditions. The first is the time delay caused by the camera in capturing of the images i.e. the delay within the camera. The second is the delay in the transmission of the images in the form of a digital signal to the PSU and the receiving of the instructions. In this paper, we account for both the delays by using the same camera that is present on the UGV. The camera is capable of converting the captured images into the appropriate format and is directly connected to the wireless transmission mechanism for transmission to the PSU. Therefore, we design a electronic circuit using PCB or Breadboard and simulate conditions equivalent to the time it would take the camera affixed on the UGV to capture an image, internally convert it into the appropriate format for wireless transmission over antennas and finally for it to display on the screen of the PSU station computer. Time delay during wireless transmission of data is considered to be negligible as it is routed via satellites. Also, retransmission of response instructions from the PSU back to the UGV is not accounted for in this paper as it basically is satellite retransmission without any time consuming components and thus is assumed to be negligible.

II. METHODOLOGY

The block diagram for the proposed mechanism is shown in Fig1. The measurement of time difference is done by constructing two different pathways. The first is to use daylight (or bulb light) to illuminate a photo switch, turning it on and giving rise to a voltage pulse we term as time pulse t1. The second pathway makes the daylight (same bulb light) fall on a camera (UGV camera) which is connected to a monitor (present at the PSU end). The monitor is kept in dark mode so that it emits no light at all and is adjusted in a way that it wakes up upon the arrival of the signal i.e. the signal acts as a trigger for monitor changing it from low power or sleep mode to active mode. This monitor light is used to illuminate another photo switch detector the time pulse achieved from which is considered as time pulse t2. The difference between the two time pulses gives us the time delay to be calculated. Considerations need to be made regarding the brightness of the daylight/ bulb light as well as the monitor screen so that it is bright enough to turn on the photo switch as every photo switch has a sensitivity point beyond which it operates.



III. CONSTRUCTION

Table 1. lists the specifications and quantities of various components that were used to construct the circuit. Figure 2. shows the diagram of the implemented circuit.

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S.NO	TYPE OF COMPONENT	SPECIFICATION	QUANTITY
1	Transistor	SL100	2
2	Potentiometer	100kohm	2
3	Resistors	lkohm	6
4	Op-AMP	IC741	2
5	Photodiode/Phototransistor	silicon	2
6	Diode	IN4001	1
7	Relay	KT603	1
8	DC Battery	9V	1

TABLE I: COMPONENTS USED

Two photo switch circuits are constructed one for each pathway. The photo switch circuit 1 consists of an NPN SL100 transistor. To the emitter, a 1k ohm resistance is connected one end of which is connected to the ground. To the collector junction, we connect another 1k ohm resistor, one end of which is at VCC. The circuit is found to run optimally for a VCC of 9V. The base terminal is connected to one end of the photodiode which is operating in reverse bias and the other end of the base is grounded. Also, a 100k ohm potentiometer is connected to the base and photodiode junction. The other end of the potentiometer is at VCC. A similar photo switch circuit 2 is made again. The output of photo switch circuit 1, through its collector junction goes to the inverting junction (pin2) of the op-amp. The output of the photo switch circuit 2 via its collector junction go to the non inverting junction (pin3) of the op-amp. Pin 4 of the op-amp is connected to VCC and pin 7 is grounded. Output of the op-amp is achieved through pin 6 across which a 1k ohm resistor is connected. The other end of the resistor goes to the base of another NPN SL100 transistor. The emitter junction of the transistor is grounded. The collector is connected to a relay and IN4001 diode junction. The relay functions like a switch for the voltage (time) pulse across and is connected to the ports of a computer software Data Input/ Output (DIO) cards for time measurement.



Fig. 2. Circuit Diagram

IV. WORKING

We account for both the pathways at once and measure the time difference between them. At any time instant (say at t=0), the experiment is started by presIng the swItch. The llght of the bulb simultaneously falls on the first elements of both the pathways namely photodiode 1 (for the direct circuit) and the camera (for the indirect pathway). The photodiode 1 converts the light into voltage and takes a single stream. The voltage stream is singly amplified through the transistor. The amplified voltage is fed to the op-amp which since is connected without any feedback, acts as a comparator & gives the output high (VCC) or low (Ground Voltage) as per the input. Further, the output voltage is fed to another transistor for more amplification after which it reaches the connected relay circuit across which the diode is connected and which acts a switch. The switch is pressed indicating the receiving of a time pulse. Across the terminals of the relay, the time pulse is received and stored using DIO cards as t1 pulse and the time taken from initial state to receiving state is measured as t1. In the second pathway, the camera captures the light in the form of an image in an appropriate format. The image captured by the camera is transferred wirelessly to a monitor who is initially in sleep state (totally dark screen) so that no light emerges out of it. The image causes a change of state in the monitor (light state) and light emerges out of it which falls on the photodiode 2 After this, the process is absolutely same as pathway 1, i.e. the conversion of light that fell on photodiode 2 into voltage and the traversing of the path to the DIO card and thus pulse t2 gets stored in the DIO card and the time taken from initial state to receiving state is measured as t2. The DIO card measures the difference between time t1 and t2 and logically this and in actuality this time difference amounts to the total time it would take a UGV camera to have real time information transferred is to the monitor.

A Computer software created using LabView that was created was connected via the Ethernet (LAN port) to Data Input/output Cards (DIO cards). The DIO cards has multiple ports/pins, 2 of which were used, one for t1 signal and one for t2 signal. The software is used to monitors the cards. In actuality, the software manages a clock in the order of milliseconds. This is done by using the computer clock as reference but programming it in the order of milliseconds. When the pulse t1 is received, the clock is set on by the software and when the pulse t2 is received, the clock is set off. This way, the time the clock was on gives us the required time delay.

V. OUTPUT

The mode of the time difference was roughly in the order of 700 milliseconds. It is found to be varying from 630ms to 780ms for successive readings. The simulations and detailed results is confidential and property of the employee organization.

VI. CONCLUSION

The paper exhibits a circuit to simulate conditions similar to the ones being used in an Unmanned Ground Vehicles to calculate the time delay in communication by an UGV with its controller. The time delay assumes significance as a considerable value could prove to be accidental for the vehicle.

ACKNOWLEDGMENT

I would like to express my gratitude to Director, VRDE for giving me the opportunity to work in the institute and use its world class equipment's and labs for the project.

I am extremely indebted to Mr. GRM Rao who acted as my guide for the project.

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