LOW COST RACE LAP TIMER WITH TIME TRACKING INTERFACE

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Abstract. Timekeeping is essential for all racing event. It includes marathon, running, car n motorcycle racing. Most of the professional racing events are fully sponsored and have their own sophisticated timing device. It is easy for the big events to have a good timing device. And most timing devices out there is expensive to be own for small events. In motor racing, every time the time is taken, it will always show the time difference between the riders. And all of this will be broadcasted into a big screen. Everyone will know where they will be placed and what is their fastest lap time. This will be a great opportunity to develop a timing device that is cost efficient and easy to be used. The Timing Device will be developed using several microcontrollers which includes Arduino and Raspberry Pi as well as other electronic components. The main idea is to use Infrared beaming and signal processing from the infrared beaming to be used in the timing device. The Webserver will then broadcast the timing result to be shown to the users and viewers. Overall, the goal for this timekeeping device is to develop a low cost timing device that can be used in different sets of racing event.

1. Introduction

Time tracking is essential in any racing events, from running, motorcycle racing, car racing, and any other types of racing events. In this modern day, many technologies have been developed to track the time of the lap, full race time, position of racers using satellite positioning (GPS) to ensure the audience can watch the racing event with ease.

Time tracking in sports racing event must have the element of data processing from the user to the broadcaster to show the time that has been recorded by the participant. The data processing includes the process of activating, stopping, recording, as well as reset the time. Then these recorded times will be broadcasted to the users and viewers.

All these modern technology is pricey and only available for professional racing events. Some of the technology can only track time only for the racer to use. This means that one device can only track time for only a participant to use without broadcasting the result to other racers. And the broadcasting is done manually by entering the time data without using any integrated software.
The first goal of this project is to develop a Timing Device which will be cost efficient to be used in all racing events. The timing device will not just benefit the organizers but the participants as well. It can improve all the racers out there to improve their time.

The second objective for this project is to develop a Timing Device that has good availability, user friendly in terms of interface as well as the timing device are easy to deploy in different places. Most timing device are only available to rent in professional circuit such as the Sepang International Circuit. With the development of this project, the timing device can be available anywhere, anytime whenever there is a racing event on going.

2. Project Objective

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3. Background

3.1. Timekeeping

At Omega’s first timekeeping assignment for the 1936 Games in Garmisch-Partenkirchen, Germany, a lone technician used 27 stopwatches to time each event. Seventy years later in Turin, Italy, Omega deployed 208 professionals – 127 timekeepers and 81 data handlers – with 220 tonnes of equipment. Those numbers will be blown away in future as companies mobilise the largest timekeeping contingent ever in winter sport. [1]

There are still in existence devices believed to have been made by the Egyptians six thousand years ago for the purpose of telling time from the stars, and there is good reason to believe that they were in quite general use by the better educated people of that period.' Since that period there has been a continuous use and improvement of timekeeping methods and devices, following sometimes quite independent lines, but developing through a long series of new ideas and refinements into the very precise means at our disposal today. [2]

Omega used the cellular photoelectric eye for the first time at the 1948 Olympic Winter Games in St. Moritz. Mobile and independent of the electrical network, it was water-resistant and could be adjusted to resist wide variations in temperature; its infrared technology was insensitive to the so-called parasitic reflection of the sun and flashes. For the first time, the timing system was triggered automatically when the starting gate opened. [3]

3.2. Serial Communication

Serial communication is common method of transmitting data between a computer and a peripheral device such as a programmable instrument or even another computer. Serial communication transmits data one bit at a time, sequentially, over a single communication line to a receiver. Serial is also a most
popular communication protocol that is used by many devices for instrumentation; numerous GPIB-compatible devices also come with an RS-232 based port. This method is used when data transfer rates are very low or the data must be transferred over long distances and also where the cost of cable and synchronization difficulties make parallel communication impractical. Serial communication is popular because most computers have one or more serial ports, so no extra hardware is needed other than a cable to connect the instrument to the computer or two computers together. [4]

Serial interfaces stream their data, one single bit at a time. These interfaces can operate on as little as one wire, usually never more than four. [5]

![Serial Interface](image)

Figure 1 Example of Serial Interface transmitting one bit every clock pulse [5]

In this project, serial communication is used to program the infrared beaming of the infrared transmitter. Infrared beaming streams their data in one bit at a time. Thus making serial communication a necessity in this project.

3.3. Arduino

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. We can tell our board what to do by sending a set of instructions to the microcontroller on the board. To do so we use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing. [6]

Arduino senses the environment by receiving inputs from many sensors, and affects its surroundings by controlling lights, motors, and other actuators. [7]

Arduino board and the IDE is used to test the infrared beaming as well as to program the ATTINY85 chip. Arduino is very useful in programming other microcontroller chip such as used in this project which is the ATTINY85.

Arduino is one of the advance microcontrollers that has been develop to ease users on learning to program. The IDE uses C programming and it is easy to be use. The IDE has a notification window just below the coding part to ensure users can know whether their code can be compiled or not. It also states the error and the users can work on the error to fix the problem. The Arduino pins can be set to control any movement on the motor. This makes Arduino the choice of the Timing device project as it can be program to control the beaming of the infrared.
3.4. **Infrared**

Infrared waves are electromagnetic radiation of a particular wavelength or color that we have named 'infrared.' They are between 700 nm (nanometers) and 1 mm. Note that 1 mm is equal to 1,000,000 nanometers. They are just beyond what our eyes can detect on the red side of the rainbow. William Herschel first discovered them around 1800. [8]

We are surrounded by infrared every moment of every day. Warm objects, such as the human body, produce large amounts of infrared, and heat-sensitive CCTV cameras work by detecting these infrared waves. Half of the energy produced by the sun is infrared, so we are being bombarded by it constantly. [8]

The most common use of infrared in everyday life is remote controls. These work by sending pulses of infrared that spell out a message to an electronic device. This device could be a television, blu-ray player, or even a computer. Infrared can be used in a similar way for communication. By sending these same pulses through fiber-optic cables, transmitting audio to sound systems, or other data through fiber-optic high-speed internet services. [8]

Infrared is used just to transfer the data of the transmitter to the receiver in this project, the codes used are mostly simple Sony remote control codes. Or other codes that is use in our daily remote control device.

3.5. **Raspberry Pi**

A Raspberry Pi is a credit-card sized computer originally designed for education, inspired by the 1981 BBC Micro. Creator Eben Upton's goal was to create a low-cost device that would improve programming skills and hardware understanding at the pre-university level. But thanks to its small size and accessible price, it was quickly adopted by tinkerers, makers, and electronics enthusiasts for projects that require more than a basic microcontroller (such as Arduino devices). [9]

The Raspberry Pi is slower than a modern laptop or desktop but is still a complete Linux computer and can provide all the expected abilities that implies, at a low-power consumption level. [9]

Raspberry Pi can be programmed to do any projects. Thus making this microcontroller or minicomputer a choice for this project. Using Linux, it is easy to code and compile the codes required.
4. Literature Review

Timekeeping has been evolved from time to time. In the early days of competitive racing event, there are no importance in recording the time taken of the participants. In those times, only the results matters. In the modern days of sports and racing, timekeeping is important to differentiate the results of the race. This is due to the lack in the human eye to detect fast motions especially in the fast paced race.

Race timekeeping in modern era includes some complicated data processing. It includes a transmitter to detect the where about of the participants and the sensors to keep track of the time.

4.1. Timekeepening in Electric Smart Meters to evaluate electricity consumption

The issues and problem that is identified to implement this system is electromagnetic disturbances when applied to the SEM. The disturbances include electrostatic discharge, electrical fast transients, voltage dips and short interruptions, electromagnetic fields radiation. These disturbances can cause error in calculation of the electricity usage thus making an error on calculating the bill for the customers. On the other hand, the software that is to be burn inside the bootloader of the microcontroller needs to have more research done to ensure efficiency of timekeeping. [10]

To solve these problems, many test on software operation development need to be done to ensure there are no miscalculation on the electricity usage. For the disturbances issue, 4 tests are conducted with different characteristics to get a better knowledge on what the disturbances effect on the static energy meters (SEM). From the 4 tests, all the results are studied and improvement are to be made on the best case scenario and the worst case scenario. Acceptance criteria is done to ensure the SEMs will be functioning efficiently with a limit of acceptance error. [10]

This paper shows a low cost and suitable method to evaluate the accuracy of timekeeping in static electricity meters (SEM) during the disturbances test. To ensure the timekeeping is accurate, many tests and improvement need to be done on minimizing the electromagnetic disturbance.

4.2. Olympic Timekeeping

Modern time keeping maintains a database of every single athlete, their names, nationalities, and rankings for even for non-timed sports like figure skating and curling. [11]
The Starting Line is now an electronic start system. Since the Vancouver games four years ago, the traditional powder pistol has been replaced with markedly less badass flash pistol. But it's also a lot more technologically sophisticated. The electronic start system simultaneously does three things: creates a flash, sets off a bang, and starts the clock. Loudspeakers transmit the sound to all of the athletes simultaneously. [11]

Depending on the sport, racetracks are also installed with laser photocells—essentially tripwires made of light—and/or athletes are fitted with small transponders that report on false starts, lap times, and finish times.

All this data from the race in progress is monitored by a few staff in a timing control booth. The timekeepers have their eyes glued to the screen to make sure all equipment is all working and every athlete timed. But all they see are numbers, no names, to help prevent any bias from leaking in. [11]

![Figure 4 How timing device communicate](image)

4.3. **Electronic Timekeeping**

Sports showcases rely on the integrity of their measuring and timing systems as much as they rely on their ability to broadcast ever more sophisticated programming to keep the punters hooked. Today’s systems are light years away from the early days when synchronised chronographs simply recorded the time the skier started and finished his run and the results were pinned to a noticeboard several hours later. [1]

This project is using the concept of broadcasting the same as the Electronics Timekeeping. But in the early days the results can only be pinned to the noticeboard after a while. This project can directly broadcast the result in real time. This is to ensure participants and viewers can keep track of their timing and their favourite participants.

5. **Methodology**

Before starting the project, research on the component is needed to ensure the prototype can be built by the end of the project. For now, all the components must be bought online and safely delivered. Next, we need to know how to use the microcontroller and the compiler to insert the code into the microcontroller. Research on using Arduino is done to ensure smooth coding and trial and error of transferring data can be done next.
When developing a software, there is also a lot of variation of development tools provided to the programmer to ease the creation of application. This tools is provided to help different programmer to choose which language they are comfortable and help them effortless create the android application they wish to build and coding the application without restricting them to one language. The tools include assistance for the programmer such as debugger, libraries, documentation, sample code and tutorial to help them through hard-hitting jammed situation when on the process of making the application.

Since development tools have different variety of language to be decide on, such as C, C++, Corona with LUA programming language, HTML, CSS, JavaScript and the most used and official language for developing an android application is Java. This provide a variety of option to choose from.

Using Arduino as one of the main microcontroller, when transferring data from one device to another device, we need to have a good knowledge in Serial Communication. Serial communication is used to transfer data from one microcontroller to another microcontroller. For starters, the research on serial communication needs to be done so the data transfer in serial communication can be done effectively.

On the other hand, the home base which is the Raspberry Pi consist of code for decoding the infrared beam and to count the time taken for each user to set their lap time. The Raspberry Pi must be perfectly coded to ensure the timing can be done perfectly. The home base will include the code for timing, webserver, interface, and timing sheets.

The other problem is to connect the transmitter to the receiver, which the transmitter is using a Attiny85 chip that stores the beaming data for the infrared to the home base which is using the Raspberry Pi. The coding for both sides must match and can be read successfully by the receiver to ensure data transfer for timing device is perfectly run.

Other than that, one of the major issue is to keep up with multiple users in using the timing device in a smooth manner. Collision must be sorted out in a good manner to ensure all users can get their timing right. The home base must keep track of all the transmitter id or transponder id and to separate them in the timesheet on the home base. The data collected must be constantly updated so the users will not encounter misinformation on the timing they have taken.

For language the program is build, the original idea of the project is to develop an application with the c language. After doing research on the language used to build a program, there are many other languages that are used in coding the home base and the transponder. The raspberry pi is a Linux base so mostly we will be using C to program with an addition of Bash script and a little of Perl. For the transponder side, it is mostly using C with Arduino syntax. All the language provides the support to generate a more complicate function of code for the use of the program as this project require different set of microcontroller to be used.

6. Implementation

This project requires specific version of the Arduino IDE. The version needed is Arduino IDE 1.6.4. This version is available from the main website under previous versions.
The transponder is where the transmitter of the infrared will be done, which will be move around the track with the user. The transponder is to start and stop time when it passes the Home Base. The schematic for the transponder is given in Figure 5.

![Transponder Schematic](image)

Figure 5 Transponder Schematic

The ATTINY85 will be the microcontroller chip to be coded with infrared beam and data for the ID for the transponder. The ID is coded so it can be use with different users and can be run simultaneously with many users.

The codes in for the ATTINY85 is mostly infrared beaming codes. It is to transmit signal to the home base to start and stop with an additional reset every time the transponder passes the start stop finish line. As stated in the diagram above, the codes are mostly bits for the infrared beaming.

The home base is where all the data will be calculated and projected into an interface connected to the computer or mobile phone. It will be connected via SSH and all the program will be inside the Raspberry Pi. The timing sheets, user’s data will all be programmed inside the home base with the webserver to connect to the user’s computer or mobile phone for the interface to work.

Official images for recommended operating systems are available to download from the Raspberry Pi Website Downloads page. This project will be using the Raspbian OS from the official Raspberry Pi Website. Download the latest Raspbian OS from the website.

As stated, the home base is using Raspberry Pi, there are many GPIO pins that can be used for the project. Mostly this pins are used to connect the receiver end of the infrared receiver. The receiver is used to take the data from the transponder which includes the transponder ID, the infrared beaming from the transponder infrared transmitter, and the algorithm to start and stop time whenever the transponder has crossed the start/stop finish line where the home base is located. The schematics or pin allocation is shown in Figure 6.

We are using 3 sensors to maximize the data signal processing between the transponder and the home base. We will be using a power bank to power up the Raspberry Pi to be used for the timekeeping. The reason we use a power bank is because of the mobility of the item so we can move the timing device of the home base anywhere.
Lastly, the connection of the sensors to the pin need to be done as shown in Figure 7. The sensor is connected to the 3.3V to supply the power to the sensors. The buzzer is just optional as it only produces sounds to give notification to the users that the transponder has been detected.

This project mostly uses infrared for signal processing, so the project is using ir daemon for the infrared beaming. There are many ir daemon out there but this project uses some simplified ir daemon that has the feature of the television remote control.

The ir_daemon is a C++ daemon running in the background of your Raspberry Pi. It's responsible for decoding IR data, receiving and sending commands from and to various sources etc.

The Raspberry Pi 3 can be an access point to other devices to connect. This project will require to configure the access point and the webserver. The webserver is where the timing sheets will be broadcasted. For Raspberry Pi, it is using a Linux System, so configuring Apache Webserver is required.

There is a specific ip address that’s need to be used in this project. These steps need to be done to configure the webserver and to ensure the connection for other users is smooth and running.

After all the codings, extractions, downloads and compiling is done, it is time to access the user interface for the Software. The main menu for the interface will be as shown in Figure 8.
The access point name is EasyRaceLapTimer. Connect to the access point. Next open the web browser, and enter the address 192.168.42.1 which has been configured as the static IP address for the Home Base webserver. After entering the address, the main interface will be loaded.

After accessing the main interface, login as administrator from the username and password that has been configured. The administrator can access, write, delete the content of the users, pilots, start and stop a race, and delete the history of any races.

There are 2 modes for the race event. One is the Standard Race Tracking and the other is Competition Race. Standard Race Tracking can be used for testing and taking casual lap time while the Competition Race is more towards and bigger scale race event.

7. Tests and Results

7.1. Prototype

As all the implementation is done, the final product will be a prototype. It includes the home base which is the Raspberry Pi 3 connected to the infrared sensors. And the transponder which includes the infrared transmitter with the coded ATTINY85 microcontroller chip. Both of the prototype is shown below in Figure 9 and Figure 10.

In this project, there are 3 infrared sensors used to ensure the sensors can detect the transponder clearly. It will be placed depending on pole that is placed on. The buzzer is used to notify that the home base has detect a transponder.

The transponder is assembled in the breadboard for testing. And in future development a Printed Circuit Board will be develop to make the transponder easy to be move around and making it smaller in size. As there is limitation on getting a 5 volt power source for lighting up the infrared led, a 7805 voltage regulator is used to modulate a 9 volt battery power into 5 volt power.

Test are taken to ensure the transponder are working well. The home base and the transponder are tested in three conditions, which is under room light condition, under direct sunlight condition, as well as under low-light conditions.

7.2. Proximity Distance Tests under Room Light Conditions
For the first test, we will test how much distance the Home Base can detect the Transponder with a full battery charge. This test is done to test how much effect the Room Light or indoor light intensity can affect the Infrared beaming intensity towards the infrared sensors at the Home Base.

For this test, we are only using one transponder with a full battery charge with the Home Based powered on and connected to the buzzer. The buzzer will make a sound when the transponder is detected.

The sensors can detect the transponder in the range of 1 to 2 meters flawlessly. this means the infrared beaming intensity is stronger than the light intensity that has some ultra violet ray that can block the infrared beaming.
The sensors still can detect the transponder between the range of 3 to 5 meters. The buzzer emits sounds that it has detected the transponder within this range. 5 meters is the width of a normal 2-way street. This means the transponder can be used in a track that has a width of 2-way street.

The sensors start having problem detecting the transponder after the 6 meters range. This is due to the wavelength of the infrared started to fade after the range of 6 meters. The buzzer emits sounds not all the time. After the 8 meters range, the sensors do not detect the transponder at all.

7.3. Proximity Distance Tests under No-Light or Night time conditions

The next test is done with the same concept as the light condition but under a NO-Light or Night Time conditions. We will be using a fully charged transponder with the home base on.

Between 1 to 2 meters range, the sensors detect the transponder without any problem. This is expected as during no-light conditions the infrared beaming will shine flawlessly. there is no blockage from other sources of light or ray during no-light conditions.

The sensors still detect the transponder without any problems within the range from 3 to 7 meters. This goes on to a larger range at 8 meters, 9 meters. At 10 meters, the sensors start having problems on detecting the sensors. This is due to the travelling range for the infrared beaming ray is large and the infrared beaming starts to fade at this distances. At 12 meters, the home base cannot detect the transponder.

7.4. Proximity Distance Tests under Sunlight

The last test is done with the same procedure as the above 2 tests. Just with an addition of it is under a direct sunlight in the middle of the day. Sunlight emits a bit of infrared ray, so this can be a distortion to the infrared beams that is produced by the transponders.

The tests gave these following results. Between 1 to 2 meters, the home base does not have any problems detecting the transponder. This means the infrared beams can work well between this range. The transponder infrared beaming ray has greater speed and doesn’t fade at this distance.

The home base can detect the transponder without any problem until the 3 meters range. At 4 meters, the transponder started to have problems picking up signals from the transponder. This means the distortion and interference from the sunlight ray that emits infrared ray starts interfering with the transponder infrared ray.

The sensors did not catch any signals from the transponder at the 6 meters range. During the sun is at the peak during daylight, the sun has greater intensity and can interfere with the transponder infrared beaming. Thus making the sensors cannot detect the transponder.

7.5. Meeting Objectives

As the project’s first objective is to develop a device that can track time by using different types of electronic components by using a system that is cheap, and it can track time and do almost all the functions that a latest professional time tracking device can do. It also comes with an integrated all racers interface that can keep track of all the racer lap time. The cost comparison is given in the table below:
Timing Device Solution Developed by Professionals | The Timing Device developed in this project
---|---
**Cost**
- Transponder rent: RM300 per 2-hour session
- Transponder bought from professionals: RM550 (some not compatible with the circuits timing sensors and timing sheets)
- Microcontrollers: RM200
- Electronic components for 1 transponder: RM55
- Rental: RM300 every one session
- Personal Transponder: RM550
- RM355 for 1 transponder with home base. Additional RM55 for every add on of transponder for life

Table 1 Comparison of cost

Currently, the technology that is used in the racing world, especially motorcycle racing and car racing is using a transponder and a receiver that is cost more than RM350 per device and this device cannot integrate other racers or participant time into one software. This project will cut all the cost and it can be available to all non-professional or non-big-scale racing events out there with integration to all participants. The second objective of this project can be shown to be fulfilled by the table below:

| Availability | The Timing Device developed in this project |
|--------------|------------------------------------------|
| - Only available in track | - Available any time after the project is complete |
| - Only available during big racing event | - Can be used in a small or closed event |

| Movability | The Timing Device developed in this project |
|------------|------------------------------------------|
| - Cannot be used outside the track | - Easy to deploy anywhere |
| - Timing | - Timing sheets can |
sheets only available in the Circuit office be accessible using mobile phones

| sheets only available in the Circuit office | be accessible using mobile phones |
|--------------------------------------------|----------------------------------|

*Table 2 Comparison of availability and movability*

8. Conclusion and Future Research

Several conclusions have been extracted after developing the program. On the process of developing the program, it is there are huge amount of project that is available to guide people to make a program which is desired but to find the right function to run the program have been a very challenging and it have taken a long trial and error to make one activity work. The compiler has provided so much tool and information on their website to guide new developer to create their program and that have provided so much help when developing this app.

The two objective has been reach as the Timing Device is cost efficient to be develop. As for the availability and movability, it is pretty much easy to assemble in any given place and time. This makes the project a success as it is cheap and user friendly.

The problem faced for this project if only the condition of the light during the race mode. When the light intensity is low, the sensors can detect the transponder perfectly well. This is due to no interference towards the infrared beaming of the transponder. If races are done using this project in under a broad daylight sunlight conditions, the sensors will have problems detecting the transponder. It can detect up till 4 meters in distance which is just enough almost the width of a 2-way street.

This prototype is perfect to use in a dark environment. A night race will be perfect with a low light condition. This is the best condition to use the prototype. This prototype is also good to be used in a remote control car race or any remote control toy race as the track width is not as big as normal bike or car race. It also can be used in a go-kart or a minigp bike race as the track width is not big.

First of all, a good printed circuit board (PCB) is a best to be used for this prototype. It will be easier for the electronic components to be soldered and assembled. For this, some research on maximizing the use of the PCB need to be done.

Next, research on maximizing the infrared beaming needs to be done because not all race events are done at night. Due to limitation on using infrared during daytime or in a high intensity light, there would be some substitute on using infrared for data transfer and signal processing.

Some of the upgrade that is for future research:

- Average time per lap
- Average speed per lap
- Standings
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