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Survey on Laser Guided Missile Systems and Implementation by Developing a Laser Guidance System

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ABSTRACT

A laser-guided missile is a projectile airborne to reach and destroy the target. The whole body is propelled to hit a predetermined target-directed through the laser beam painting towards a target. The laser is aimed to point at the goal object and its central position from the robot missile. If the target changes its initial position, the camera tracks the new position, and information is fed to an onboard computer of the missile as visual feedback, which computes a new trajectory for itself by steering its body and chasing towards the direction of

the new target and hitting it with improved accuracy. This whole system of guiding and making changes according to new information has to be updated every time instantaneously and should be made entirely automated and not controlled by any human. To design such a Stable, Accurate, and Spontaneous system lot of parameters have to be seen in Electronics and Aerodynamics. A detailed survey is made on the most available Laser Guidance System for analyzing the best way to design. This paper discusses the proposed Laser guided system developed using Raspberry-pi controller.

Keywords: Laser beam, Guidance System, Raspberry-pi Accuracy and stability.

I. INTRODUCTION

A guidance device consists of devices that are implemented on controlling the movement of a missile or other moving object. Every movement within the missile from the start line till it reaches the target is about and goes past the system. Here we are studying a laser-guided system for the missile. Guidance is that the process of calculating the initial and changes in its position, velocity, altitude, and rotation rates of a moving object within the air required to follow a particular trajectory [1].

A laser-guided missile could be a V-1 that strikes its target with incredible precision employing a laser for tracking its target; the target is often stationary or moving.

A guidance device consists of three sections: Input section, Processing unit, and Output section. The input section includes sensors, data, radio and satellite links, and other information sources. The processing unit integrates this data and determines the specified actions (if any) that are to be taken for achieving a correct heading. The processing unit is directly fed to the outputs which directly affects the system's performance. The output section controls velocity by interacting with devices like motors for thrust or by actuating ailerons, rudders altering directly. Components in the system include; targeting or guidance system, flight system, engine, and warhead.

During the first 1950s, the federal government did not want to be over-dependant on the German team in order that they tried to insulate themselves for military applications. One of the people who were "developed" domestically was missile guidance. MIT Instrumentation Lab, chosen by the Air Force, to produce a self-contained system backup in San Diego for the new inter-continental missile named Atlas.

The first missile developed by Nazi Germany in war II which was used operationally was a series of missiles. The famous ones in every of these are the V-1 buzz bomb and V-2 rocket, both of them are consisting of a mechanical autopilot keeping the missile on the wing mode along a pre-chosen route. Less well-known was a series of Anti-Ship and Anti-aircraft missiles, typically supported a straightforward direction system directed by the operator. However, these early systems were in-built small numbers [2].

II. LITERATURE SURVEY

The below table has a collection of information, research made across various countries and published in conferences related to Guidance System.

TABLE I. LIST OF GUIDANCE SYSTEMS PUBLISHED IN CO

	Year	Conference Name, *Place* & **Author**	Title	Pros	cons
1	2008	Intl. Conf. On Control, Automation, Robotics, and Vision *Hanoi, Vietnam* **Hla Myo Tun**	Design Analysis of Phase Lead Compensation for Typical Laser Guided Missile Control System Using MATLAB Bode Plots	The final lead compensator network has been designed to increase stability using MATLAB[15]	-
2	2008	First Intl. conf. On Intelligent networks and Intelligent systems *Chengdu, China* **Ke Zhang, Wei Zhang**	A Design of Data fusion software system for laser Radar and FLIR	The design in this article collects information by FLIR and achieves a new method of control and guide with multisensory. [7]	-
3	2011	IE EE *Shijiazhuang, China* **ZHOU Zhong-Liang**	Study on image processing technology in imaging laser detection system	Image Processing was a very effective way for improving system's performance[8]	-
4	2012	International Conference on Optoelectronics and microelectronics *Changchun, China* **Keyan Dong**	The optical system design of transmissive laser target simulator	As the projection system design is closer to the actual environment, this system can **simulate** the imaging of the far-field target under near-field conditions.	Due to the size and shape of the diffuse reflection screen, the spot position simulation is limited only to a small area.[9]
5	2013	Journal of the institution of engineers *India* **Rajesh Joseph Abrraham**	Application of a complex lead compensation for a laser-guided missile	Compensator system design can be applied for efficient system modeling and loop shaping which gives better results.	Smaller high-frequency gain of the complex lead compensator tends to increase the high-frequency noise rejection when compared to the double lead compensator. [10]

6	2014	IEEE *Melbourne, Australia* **Roberto Sabatini**	Innovative flight test instrumentation and techniques for airborne laser systems performance analysis	The software tool used for 3D simulation is available for both training mission planning and post-mission data analysis.	The exact nature of the correlation between the various SPD has not been identified. [11]
7	2017	IEEE *Gurgaon, India* **Hemani Kaushal**	Applications of laser for tactical Military operations.	This weapon when used as range finders, LIDARs, target designators, they serve as a powerful tool to the war-fighters.	As this is a directed high-energy weapon, it requires a sufficient amount of power. Also, during unstable weather conditions, these weapons can deflect and can miss the target. [12]
8	2019	Journal of systems engineering and electronics *China* **ZHANG Jiandong, SHI Gouging**	A Quantitative Method for calculating irradiation area of target designator	Based on the laser transmission model and the motion model, an algorithm was made for measurably calculating the irradiation area of the laser target.	After comparing the simulation results of different irradiation fields, it was seen that the shape of the reflection surface greatly affected the size and shape of the irradiation field. [13]
9	2020	IEEE *China* **QIJIA YUN, YANG PEI**	Modeling the impact of high energy laser weapon on the mission effectiveness	Between the mission effectiveness and the subsystem design parameters, an SoS view of the relationship is established through a mission scenario.	As the power supply is limited it might lead to insufficient battery capacity, which leads to system shutdown in the middle of the engagement during flight. [14]

III. RELATED WORK

1) In 2008, Hla Myo Tun, et al explained the lead compensator, designed to increase stability using MATLAB[15]
2) In 2008, Ke Zhang, et al
3) In 2011, ZHOU Zhong Liang, et al
4) In 2012, Keyan Dong, et al
5) In 2013, Rajesh Joseph Abrraham, et al

6) In 2014, Roberto Sabatini, et al
7) In 2017, Hemani Kaushal, et al
8) In 2019, ZHANG Jiandong, SHI Gouging, et al
9) In 2020, QIJIA YUN, YANG PEI, et al

IV. METHODOLOGY

The RaspberryPi 3 model B+ is taken as an onboard computer that runs OpenCV package for image/video analisis, which in turn is fed by a camera, then the computed data is sent to PCA9685 through GPIO pins on the RaspberryPi which helps in giving control over the servos. The servos which are connected to the control surface help with steering in 3D. For producing thrust BLDC motor is connected to its Electronic Speed Controller (ESC) which takes command from Raspberry Pi and produces Constant thrust.

A. Block diagram.

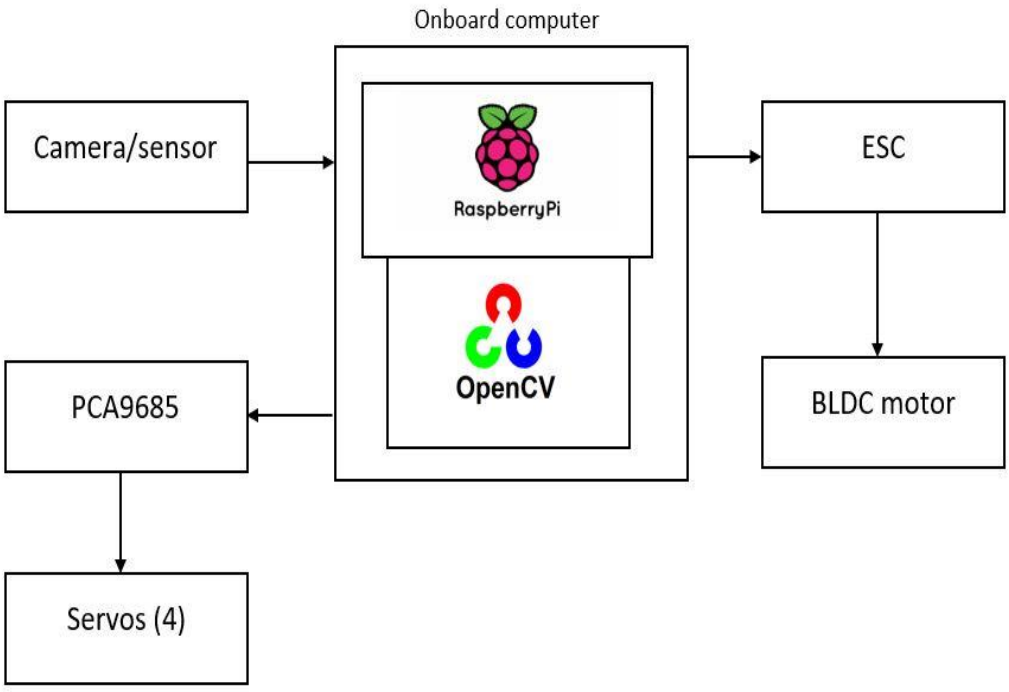

Fig.1: Block diagram of the connection of components to the missile

B. Hardware and software requirements.

- *Hardware Used*

Table 1: Hardware components used

S.N	**Hardware Components**	**Specification**	**Description**
1	Rpi Camera	5 mega-pixel	Acts as a sensor and video feed to Rpi.
2	Raspberry pi 3 Model B+	Broadcom BCM2837B0 64Gb ROM 1GB SDRAM	The video feed is processed in OpenCV and the output is given to the servos through PCA9685.
3	Adafruit PCA9685 servo driver	16-channel 5v operation voltage 25MHz internal oscillator	Gives a servo-independent power supply and a smoother PWM signal.
4	Servo motors	SG90 model 180-degree freedom of motion	Control the ‘control surfaces’ to maneuver in 3D.
5	ESC (Electronic speed controller)	16.3g 7-26V and 30A max	Control's the speed of the BLDC motor.
6	BLDC motor	2200KV	Used for producing thrust.
7	Li-po battery	3 cell 11.1V	On-board power source.

Software Used.

1. Thonny IDE(python 3.7)

Thonny is an Integrated Development Environment (IDE) for python which is designed and developed for beginners. Thonny IDE supports for C-Python and Micro-Python. This program works on Windows, Linux, and macOS. It is available as a binary bundle that includes a pip-installable package or python interpreter. This software is used for explaining Variables and memory by using a simplified model (name → value) or by using a more realistic model (name → id → value). It can be installed using the operating system package manager on Raspberry Pi, Ubuntu, and Fedora.

FUTURE RESEARCH DIRECTIONS

A large and sufficient amount of power, most preferred in watts, is required for the design and testing of high laser weapons. These high-power transmissions cause serious challenges during field testing. Therefore, the performance of these systems has to be estimated under a controlled environment. Many experiments have come up

as a very important challenge because the third domain is now gaining development, maturity, and configuration safe, comprehensive, and cost-effective for high experiments.

Also, high-energy laser generation systems require efficient cooling mechanisms which have the capability for maintaining stable temperatures during transmission cycles.

The most important consideration when handling high-power laser transmission is minimizing fatal accident and threats to friendly sensors and equipment which is nearby.

RESULT

The laser colour is detected and tracked by the onboard computer and guides the missile towards the target on which the laser is painted. Fig-3 shows the identification and tracking of red colour lasered target as an example. This missile has the capability of striking the designated target accurately 50% of the time.

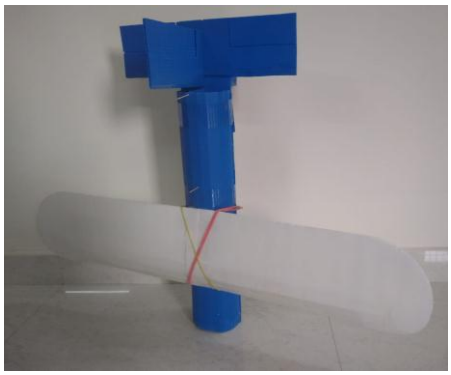

Fig 2: Missile body

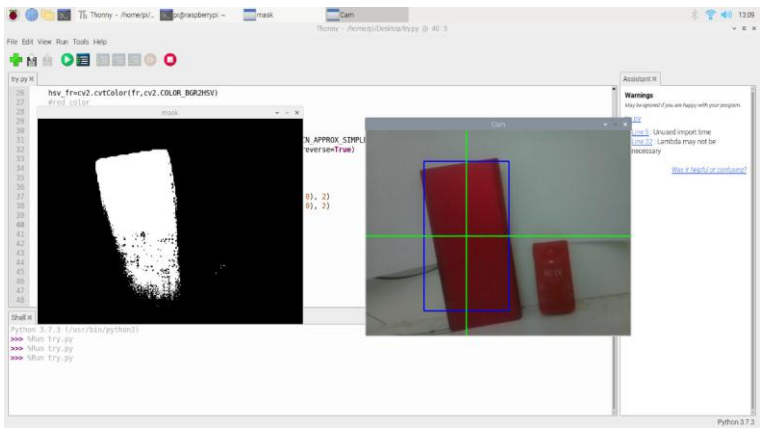

Fig-3: Output of program identifying the target.

CONCLUSION

Laser technology has shown a strong ability to transform modern-day battlefield structure, through supportive defensive and offensive applications. The lasers also serve as a powerful device for the soldier or battler when they are employed as target-designators, range-finders, LIDARs, and secure communication systems. Laser technology has made amazing progress over the past decades. This paper reviews the laser applications and projects related to strategic defence actions both on the land surface and in space. It has also covered an extensive overview of diverse laser-based projects of the last decade.

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