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A Proposal for: An investigation into a small footprint heat-source tracking solution

by
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Project submitted as part of the requirements for the
award of
BEng (Hons) Embedded Electronics Systems

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1 Introduction

This project sets out to create a low-cost solution for tracking a hot object from a moving platform. Although the references quoted are closely intertwined with military technology, there are non-military applications for this technology, which has been the main driver for technologies in this field [1], [2]. A few proposed applications of this technology are:

- Child and pet monitoring cameras,
- Factory hazard (fire) monitoring,
- Venue security – tracking naked flames or pyrotechnics,
- Videography – tracking people and vehicles,
- Aircraft tracking,
- Missile tracking,
- Other miscellaneous heat-emitting object tracking.

Low-cost solutions do not currently exist and are often targeted at high-end military platforms [1]. Some lower cost solutions use artificial sources of infrared (IR) radiation to estimate the position and orientation of an object, for example the head of a person sitting in front of a computer [3], in order to provide feedback to an artificial 3D environment displayed on a screen [4]. These types of solutions would not work when the object designated to be tracked has not already had tracking features placed upon it.

This project would aim to produce an article capable of tracking the hottest object in the field of view (FoV) of a sensor, while both the object and the platform are in motion. The article should be able to track a moving object whilst being hand carried by the investigator. Upon successfully completing this, mounting the sensor assembly to faster platforms could be investigated.

Following successful testing and integration of sub-assemblies, this project should produce:

- A battery powered sensor and gimbal assembly.
- A test and control box to represent the scene the sensor sees and manually control the article.

2 Background to the Project / Literature Review

Infrared Search and Track (IRST) do more than their title suggests. They often also contain algorithms for classifying objects and, in the case of moving objects, tracking them as defined by their control law. These systems see heavy use in airborne applications where a platform is required to “passively search, detect, track, classify and prioritise multiple airborne targets under all aspects” [2]. This project will be conducted in a ground environment but will apply lessons identified in airborne applications of IRST technology.

A few examples [5-7] depict a scenario where a sensor is pointed in a designated direction in three-dimensional space by generating commands in two axes configurations, either roll-pitch, yaw-pitch, or pan-tilt. [5] describes a pan-tilt gimbal used to scan an IR sensor across a room to take temperature measurements with the goal of determining thermal comfort. Although these researchers describe the gimbal as a pan-tilt type, the axes of rotation are the same as a roll-yaw system.

Both [6] [5] describe similar systems which use a roll-pitch and yaw-pitch gimbal respectively, to point a seeker which has been “installed on [a] rotating platform” [6]. These researchers are primarily evaluating line-of-sight (LoS) estimation and stabilisation, to track moving objects. Line-of-sight is a measure of how fast an object is moving across the field of view (FoV) of a sensor, so accurate estimation and stabilisation are essential if the tracking motion is desired to be perceived as smooth.

These systems use a gimbal which controls two-axes of the sensor, directing it to point at objects within a 360° in azimuth space and a 180° in elevation. For this project, it is proposed that a two axes system is used to reduce the overall size and complexity of controlling the gimbal.

3 Project Design

3.1 Subsystem breakdown

The overall system will be broken down into the following subsystems represented below in Figure 1:

- Sensor assembly
- Gimbal and power assembly
- Test and control box

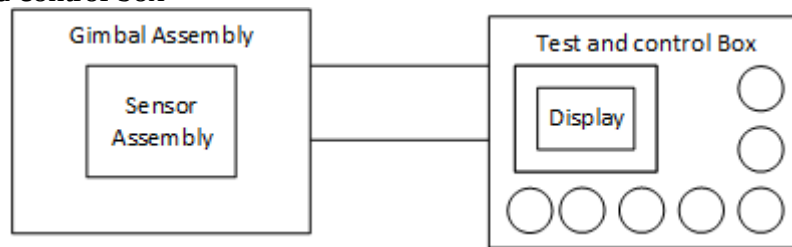


Figure 1: A high-level overview of the proposed system

3.2 Sensor assembly

The system will initially be constituted of breakout boards for various sensors but if the assembly of various components do not allow for them to be assembled into a gimbal, Electronic Design Automation (EDA) software will be used to lay out components required to operate the system instead. Use of EDA would allow for components to be placed on fewer Printed Circuit Boards (PCBs) than individual breakout boards targeted at research and development. Examples of EDA software include Altium Designer [7], Easy-PC [8], KiCad [9].

The sensor assembly will be composed of at least an IR sensor. Further research and development efforts are required to decide where the digital signal processor responsible for taking raw sensor data should be physically placed within the system. It will either reside in the sensor assembly, or the gimbal assembly.

3.3 Gimbal and power assembly

Upon completion of the sensor assembly, a gimbal assembly can be designed in 3D Computer Aided Design (CAD) software to be 3D printed. Examples of 3D CAD software include: SOLIDWORKS 3D CAD [10]; Fusion 360 [11], FreeCAD [12]. This will then be fabricated with a Fused Deposition Modelling (FDM) 3D printer, a technology suitable for rapid prototyping [13].

Integration of the sensor assembly into a gimbal assembly capable of delivering continuous rotation in the roll axis requires the use of slip rings, which “transmit electric power and/or information between continuously rotating structures and stationary equipment” [14].

The gimbal assembly will be composed of at least: two motors to move the camera in roll and yaw; a roll frame that allows the camera to rotate in the roll axis; a yaw frame that allows the camera to rotate in the yaw axis; a battery to power the gimbal and sensor assemblies and a slip ring to pass power and data to the sensor assembly.

3.4 Test and Control Box

Once component level testing is complete for the sensor assembly, a test and control box should be created to

The test display should show at a minimum:

- A representation of what the infrared sensor sees,
- The horizontal and vertical coordinates of the hottest object in the field of view

3.5 Tooling

Soldering will be used to connect components mechanically and electronically and/or breakout boards to a PCB and/or breadboard. A multimeter will be used to confirm continuity and voltage levels throughout the assemblies.

3.6 Data collection and analysis

Verification of component operation will be made possible using an oscilloscope to log raw signals, a logic analyser to log high data rate busses.

4 Resources and Planning

The deliverables for this project are:

- 1) A Sensor assembly
- 2) A Gimbal and power assembly
- 3) A Test and Control Box

These components are detailed in 3 Project Design.

Appendix A contains a Gannt chart for this independent project.

A completed ethics form is available as Appendix B – “2111739 Independent Project SoAC Ethics Form”

5 References

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6 Appendix A – Project Gantt Chart



gant_chart.pdf

7 Appendix B - 2111739 Independent Project SoAC Ethics Form



2111739 Independent Project SoAC Ethics Form.pdf

Independent Project

2111739

Joshua Asare

Project start: Mon, 10/7/2024

Beng Embedded Electronic Systems ACCAGSD20

TASK	PROGRESS	START	END
Project Proposal			
Ethics Form	100%	10/10/2024	11/10/2024
Initial Research	100%	07/10/2024	15/10/2024
Market Research / Product Comparison	100%	11/10/2024	21/10/2024
Proposal Writeup	100%	14/10/2024	24/10/2024
Review of Proposal	95%	21/10/2024	26/10/2024
Due Date	0%	26/10/2024	26/10/2024
Specification			
Camera Research and Selection	0%	07/10/2024	16/10/2024
Processor Research and Selection	0%	07/10/2024	21/10/2024
Camera Mount Research	0%	21/10/2024	31/10/2024
Stabilisation Research and Selection	0%	21/10/2024	31/10/2024
Identify risks	0%	07/10/2024	10/10/2024
Sensor assembly and global design			
Order selected components	0%	04/11/2024	14/11/2024
Await delivery of components	0%	11/11/2024	21/11/2024
Assemble first sensor prototype	0%	20/11/2024	20/12/2024
Design and print first global prototype	0%	20/11/2024	20/12/2024
Assemble first global prototype	0%	21/11/2024	20/12/2024
Component testing			
Test sensor circuit	0%	06/01/2025	16/01/2025
Write sensor control software	0%	11/01/2025	20/02/2025
Test global circuit	0%	06/01/2025	16/01/2025
Write global control software	0%	11/01/2025	20/02/2025
Design and build Test and Control Box	0%	06/01/2025	12/02/2025
Independent project deliverables and Misc.			
Supervisor meetings	0%	05/12/2024	05/12/2024
Supervisor meetings	0%	12/12/2024	12/12/2024
Supervisor meetings	0%	06/01/2025	06/01/2025
Supervisor meetings	0%	20/01/2025	20/01/2025
Supervisor meetings	0%	06/02/2025	06/02/2025
Supervisor meetings	0%	20/02/2025	20/02/2025
Supervisor meetings	0%	06/03/2025	06/03/2025
Supervisor meetings	0%	20/03/2025	20/03/2025
Supervisor meetings	0%	03/04/2025	03/04/2025
Supervisor meetings	0%	17/04/2025	17/04/2025
Interim Viva	0%	12/01/2025	16/01/2025
Final Report	0%	27/02/2025	26/04/2025
Final Viva	0%	26/04/2025	06/05/2025
Exhibition Poster	0%	26/04/2025	06/05/2025
Exhibition Questionnaire	0%	06/05/2025	06/05/2025
Non-project commitments			
EE2 2 Assignment Work	100%	06/12/2024	12/12/2024
EE2 2 Assignment Due Date	0%	16/12/2024	16/12/2024
Christmas Break	0%	26/12/2024	05/01/2025
Work Project	100%	26/10/2024	05/11/2024
Work Conference	0%	09/03/2025	21/03/2025
Good Friday	0%	04/04/2025	04/04/2025
Easter Monday	0%	21/04/2025	21/04/2025
Early May Bank Holiday	0%	05/05/2025	05/05/2025

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