FORMALIZAÇÃO DE TESE / THESIS FORMALIZATION

Título / Title

Development of an Intelligent and Efficient System for Monitoring and Optimising Sailboat Navigation

Estudante / Student

Número/Number: 1200883

Nome/Name: Henrique Manuel de Almeida e Silva dos Santos Teixeira

Orientador no ISEP / Supervisor at ISEP

Nome/Name: Luís Miguel Moreira Lino Ferreira

Sigla/Initials: LLF

Problema (obrigatório) / Problem (mandatory)

The performance of a sailing boat is determined by the shape of its sail, which can be modified by changing various settings on the boat. This is usually an empirical and complex process based on comparisons with other boats to find the most suitable settings.

Ideally, the best sail shape for a specific boat should be determined in various wind and sea conditions and then used in regatta conditions – this is the main objective of this project.

The following figure shows an example of the application of a line detection algorithm, in which an approximation of the orange to light blue line can be seen. From this image, it is then possible to determine the angle of exit and entry of the air flow, as well as other parameters.

It should be noted that an application has already been developed for Android with some functionalities.
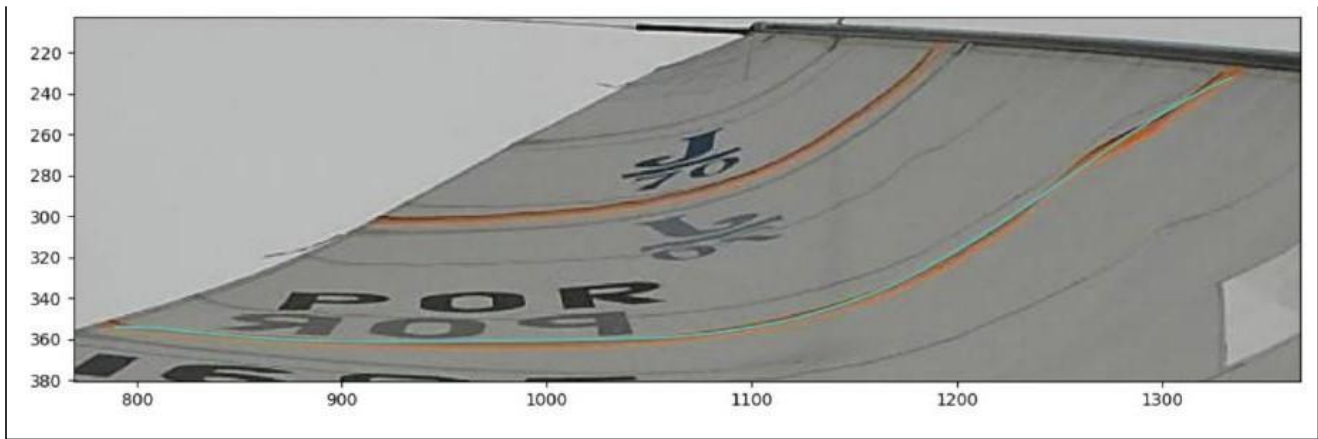
Objetivos (obrigatório) / Goals (mandatory)

The main objective is to determine the parameters of a sailing boat sail.

- State-of-the-art analysis

- Use an AI-based algorithm to determine the position of the lines more quickly and at lower computational cost;

- Optimise the operation of the system, consisting of a camera (GoPro) and a tablet, in order to save more battery power or, eventually, propose a new architecture;

- Add more data acquisition to the systems, namely acceleration in the 3 axes, inclination, speed (in real time) and course;

- Build an organised dataset with the various types of data;

- Using the data on acceleration on the 3 axes, inclination, speed and course, the aim is to determine the type of wave, whether the boat is going up or down a wave, and advise the sailor on what to do, etc.;

- Connect the system to other navigation systems on the boat (optional).

- Extend the system so that other camera models can be used (optional).

Resultados expetáveis / Outcomes [1]

Conhecimento e Compreensão / Knowledge and Understanding

For this work, the approach involves a critical concentration of knowledge in the areas of artificial intelligence (AI), computer vision, and embedded systems, applied to the context of sailing. The application of these technologies in monitoring and analysing the position of the sail lines requires multidisciplinary knowledge, encompassing concepts of AI, image processing, implementation of an Android application, and energy optimisation.

---

[1] EUR-ACE Framework Standards and Guidelines for the Accreditation of Engineering Programs, https://www.enaee.eu/eur-ace-system/standards-and-guidelines/#standards-and-guidelines-for-accreditation-of-engineering-programmes.

Análise em Engenharia / Engineering Analysis

Analysing the problem involves understanding the specific challenges of sailing and identifying the most effective AI methods for accurately detecting sail lines in different conditions. This approach includes selecting image processing algorithms and techniques that can be run on low-power devices such as a GoPro and a tablet. The analysis also covers the definition of parameters such as acceleration, speed, and tilt, which are essential for evaluating the performance and safety of the navigation system.

Projeto de Engenharia / Engineering Design

This project uses an advanced design approach to create an efficient solution that integrates a computer vision system capable of identifying the position of the sail lines and providing relevant data to the sailor in real time. The designed solution aims to optimise battery consumption and make the system compatible with different camera models. In addition, the project envisages the construction of an organised dataset and the integration of the system with other navigation devices, with the aim of maximising the accuracy and usefulness of navigation recommendations.

Investigação / Investigation

Different AI approaches and image processing techniques will be investigated to find the most effective and efficient solution for detecting lines on the sail. The research includes, among others, the investigation of Convolutional Neural Networks (CNNs) and computer vision algorithms to compare their performance in terms of accuracy and computational consumption. Through testing with specific datasets, it will be possible to define the most appropriate method for different lighting conditions, movement, and viewing angles.

Prática de Engenharia / Engineering Practice

Implementation of the algorithms referred to in the previous points.

Capacidade de Decisão / Making Judgments

Technical decisions will be based on the analysis of the algorithms' performance in terms of line detection accuracy and energy efficiency. The system will be evaluated through tests in real navigation conditions (if possible), where factors such as real-time response, battery life, image processing, and the system's adaptability to different camera models will be observed. Then, with feedback from the tests, continuous adjustments will be made to optimise the solution.

Capacidade de Comunicação e Trabalho de Equipa / Communication and Team-working

The project will contribute to the development of communication and management skills, especially in the organisation of experimental activities and receiving feedback from the supervisor, both on how to observe the algorithms and on writing the report.

Documentation writing and presentation skills are essential for sharing project results.

Aprendizagem ao Longo da Vida / Lifelong Learning

This thesis project promotes the development of autonomy and self-learning skills, as it requires continuous and in-depth research into AI algorithms and computational cost reduction technologies. In addition, students will be encouraged to explore new methodologies and evolving technologies in the field of computer vision and embedded navigation systems, thus developing a solid foundation for adapting and evolving their skills throughout their professional careers.