

## **Title: Real-Time Face Tracking with Head Mounted Displays: A Feasibility Study**

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### **Acknowledgments**

I would like to express my deepest gratitude to **Prof. Alessandro Naddeo** for providing me with this opportunity and for his continuous support throughout my internship.

I would also like to extend my special thanks to my advisor, **Dr. Bahar Çelik**, for guiding me in many areas where I had no prior knowledge, both before and during the internship. I am especially grateful to her for facilitating my introduction to this team and helping me gain these valuable experiences.

I am also sincerely thankful to **Prof. Nicola Capetti** for his valuable assistance with the project research and for sharing his expertise.

A special thanks to **Dr. Carlotta Fontana** for her readiness to help and for providing guidance throughout the research process.

I am also grateful to **PhD Candidates Mattia Cozzolino and Alfonso Magliano** for their support in helping me adapt to the country during my internship.

Finally, I would like to extend my gratitude to the entire **Dipartimento di Ingegneria Industriale (DIIN)** team for their warm hospitality.

### **Abstract**

This study explores the feasibility of real-time face tracking of surrounding people using Head Mounted Displays (HMDs). The project identifies key challenges, including limited software support, knowledge gaps, and regulatory constraints, and suggests potential solutions for future research and development.

## 1. Introduction

The project titled "**Real-Time Face Tracking with Head Mounted Displays**" was conducted as part of an Erasmus+ internship program at UNISA (**Università degli Studi di Salerno**). As an Erasmus+ internship student from the **Kutahya Health Sciences University, Department of Computer Engineering**, I, **Ismail Ozyurt**, was responsible for researching, developing, and implementing various face-tracking methodologies using Head Mounted Displays (HMDs). This report serves both as documentation of the project and a reflection of my learning experience throughout the internship.

The primary aim of this project is to enable real-time tracking of surrounding faces using HMDs, which has significant potential applications in augmented reality (AR) and virtual reality (VR). Currently, most existing studies focus on tracking the face of the wearer, rather than the surrounding people. This project addresses this gap by extending the capabilities of HMDs to detect and track multiple faces in real-time. Achieving this goal could enhance interactive applications in areas such as gaming, remote communication, and collaborative virtual environments.

## 2. Literature Review

A review of the existing literature shows a lack of recent research on real-time face tracking of surrounding individuals using HMDs. Most studies focus on tracking the wearer's face to enable avatar representation or facial expressions. Some relevant studies include:

- **Yu & Park:** Their work on real-time facial tracking in virtual reality primarily addresses the wearer's facial movements. While this offers some insight into the challenges of integrating facial tracking software with HMDs, it does not extend to multiple face tracking.
- **Girado & Peterka:** They developed a neural network-based face tracker for VR, focusing on optimizing tracking speed and accuracy for a single user.
- **Chen & Gao:** Investigated real-time 3D face reconstruction and gaze tracking, which aligns with aspects of face detection but lacks an approach for tracking multiple individuals.
- **Lugrin & Zilch:** Discussed real-time face and body tracking for avatar representation, which highlights challenges in body movement detection but does not directly tackle surrounding face tracking.

Additionally, regulatory constraints imposed by the European Union limit access to certain recent studies and data, posing another challenge to advancing this research area.

### 3. Methodology

Given the limited expertise and available resources, the project utilized AI tools to understand and implement various coding techniques and methodologies. The primary development environments were Unity and Unreal Engine, chosen for their robust 3D rendering capabilities and compatibility with VR devices. Programming languages used included C# for Unity development and Python for algorithm integration.

#### *Tools and Technologies:*

- **Programming Languages:** C#, Python
- **Development Environments:** Unity, Unreal Engine
- **Face Recognition Libraries:**
  - **dlib:** Initially tested but failed to run due to unknown errors on the current hardware setup.
  - **OpenCV:** Python-based scripts were developed to perform face detection. However, the scripts could not be integrated successfully with Unity or Unreal Engine due to synchronization and compatibility issues.
  - **VGG Face:** A deep learning-based model implemented to enhance face recognition accuracy. Despite its theoretical promise, practical integration challenges persisted due to software limitations and performance constraints.

#### *Steps Taken:*

1. **Initial Setup and Testing:** Configuration of Unity and Unreal Engine for facial tracking experiments.
2. **Algorithm Selection and Implementation:** Various algorithms (dlib, OpenCV, VGG Face) were implemented and tested for real-time face detection.
3. **Integration Attempts:** Python scripts were created to enable communication between the face tracking algorithms and the game engines.
4. **Evaluation and Analysis:** Performance metrics (such as detection accuracy, frame rate, and latency) were analyzed to assess the feasibility of the implementations.

## 4. Experimental Results

The experiments revealed several critical challenges that impacted the project's feasibility:

- **Software Support Limitation:** The Varjo SDK does not offer direct software support for face tracking, as confirmed by Varjo support. This limitation hindered the ability to fully leverage the Varjo XR3 HMD capabilities.
- **External Expertise and Guidance:** Consultation with professors revealed limited expertise in real-time face tracking using HMDs, making it challenging to find guidance or existing frameworks to build upon.
- **Regulatory Restrictions:** The professor who assigned this project mentioned that the European Union has imposed restrictions on research in this area, further limiting access to relevant studies and datasets.
- **Integration Issues:** Attempts to use external cameras (e.g., ZED Mini) with the Python scripts for OpenCV and VGG Face failed due to compatibility issues with game engines, resulting in synchronization problems, low frame rates, and inaccuracies in face detection.

## 5. Challenges and Limitations

The project encountered several challenges and limitations that affected its success:

- **Knowledge Gaps:** Due to limited expertise in the specific area of real-time face tracking with HMDs, the project relied heavily on AI tools and online resources, which only partially bridged the gap.
- **Lack of Software Support:** Varjo XR3 HMD, which was essential for the project's real-time tracking goals, lacked direct support, as confirmed by the Varjo support team.
- **Regulatory and Research Constraints:** Certain studies related to this technology have been removed or restricted by the European Union, complicating the research process and access to data.
- **Algorithm Limitations:** While both OpenCV and VGG Face algorithms have proven effective in controlled environments, their integration with game engines was not feasible due to performance issues and compatibility limitations.

## 6. Conclusion and Evaluation

Achieving real-time face tracking with the Varjo XR3 HMD is currently unfeasible due to the lack of software support, knowledge gaps, and regulatory constraints. Future efforts should focus on:

**Collaborating with Experts:** Working with professionals who specialize in HMDs and real-time facial tracking could help overcome current limitations.

**Improving Software Support:** Engaging with companies like Varjo to develop more robust SDKs that support face tracking.

**Exploring Alternative Methods:** Testing different combinations of hardware and software, such as using other HMD models or integrating more advanced algorithms.

**Addressing Regulatory Issues:** Navigating European regulations or finding alternative datasets outside of restricted regions.

## 7. Appendix

- **Software and Code Snippets:**
  - **OpenCV Face Tracking Script:** Python script used for face tracking with OpenCV. [View Script](#)
  - **VGG Face Algorithm Integration Code:** Python script used for face tracking with the VGG Face algorithm, designed for integration in Unity and Unreal Engine. [View Script](#)
- **Correspondence:**
  - **Varjo Support Team Response:** For the response from Varjo support regarding the lack of software support for face tracking, see the document here: [Varjo Support Response](#).
  - **Professor Alessia Saggese Response:** For the response from Professor Alessia Saggese regarding expertise limitations and challenges, see the document here: [Alessia Saggese Response](#).
- **Project Progress Images:**
  - **OpenCV Process Images:** Photos documenting the process and challenges encountered during the use of OpenCV for face tracking. [View Images](#)
  - **VGG Face Algorithm Process Images:** Photos documenting the process and challenges encountered during the use of the VGG Face algorithm for face tracking. [View Images](#)

## 8. References

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