T5

Capstone Report

Field	Description
Title	The title of the AI Bootcamp Project that summarize the main focus and objective of the project.
Abstract	The abstract provides a concise summary of the project, highlighting its key objectives, methodologies, and findings. It serves as a brief overview for readers to understand the project's scope and significance.
Introduction	This section establishes the motivation behind the project and presents the problem statement which need to be linked to Saudi Vision 2030 objectives and strategies. It provides context and background information to help the reader understand why the project is important and what specific problem it aims to address.
Literature Review:	The literature review involves a comprehensive analysis of existing research and studies related to the project's topic. It examines the current state of knowledge, identifies gaps or limitations in previous work, and highlights relevant theories, methodologies, or frameworks that inform the project's approach.
Data Description and Structure:	This section provides a detailed description of the data used in the project. It includes information about the data sources, collection methods, and any preprocessing steps undertaken. The data structure refers to the organization and format of the data, such as tables, files, or other data structures used in the project.
Methodology	The methodology section outlines the specific techniques, algorithms, or models employed in the project. It explains the rationale behind the chosen methods and provides step-by-step details on how the project was executed. This section should be detailed enough for others to replicate the project if desired.
Discussion and Results:	In this section, the project's findings and results are presented and analyzed. The discussion interprets the results, compares them with previous research or expectations, and provides insights into the implications and significance of the findings and how the obtained solution has on impact on achieving objectives of Saudi Vision 2030. It may also address any limitations or challenges encountered during the project.
Conclusion and Future Work	The conclusion summarizes the main findings of the project and restates its significance. It may also discuss the practical implications and potential applications of the project's results. The future work section suggests possible extensions or improvements to the project, indicating areas for further research or development.
Team	

TWWAF | طَوَّاف

TWWAF طَوَّافُ:
Autonomous Pilgrims Wheelchair

TWWAF Meaning:

الطَّوَّافُ :الخادمُ يخْدِمُ برفقٍ وعناية [1]

It means “The servant serves the companion and takes care of him softly and with care “

[1] Reference

Abstract

The TWWAF project introduces an AI-based autonomous wheelchair, specifically designed to address the navigation needs of elderly and special needs individuals during Umrah pilgrimages. Aligned with the visionary objectives of Saudi Vision 2030, the project aims to significantly enhance pilgrims' safety, convenience, and overall spiritual journey. This project involves detailed hardware components, AI architecture, and deep-learning models.

Introduction

The annual pilgrimages of Hajj and Umrah, steeped in spiritual significance, draw millions to the sacred sites. Within this diverse group, special attention is due to the elderly and those with special needs, facing challenges during the rites of Tawaf and Sa'i, necessitating reliable navigation support.

Current solutions, manual wheelchairs operated by helpers and self-driven electronic wheelchairs, while well-intentioned, present challenges. Manual wheelchairs demand substantial human resources, and straining logistics, while self-driven electronic wheelchairs pose risks for the elderly and contribute to congestion. On the other hand, self-driven electronic wheelchairs introduce risks for the elderly and contribute to congestion due to the varied skills of users.

In response, the TWWAF project, an AI-based autonomous wheelchair, emerges as a beacon of innovation. Tailored for Hajj and Umrah, it addresses navigation challenges for the elderly and special needs pilgrims. Beyond immediate problem-solving, TWWAF strategically aligns with Saudi Vision 2030, contributing to the objectives of accommodating a growing number of pilgrims, enhancing services, and enriching the religious and cultural experience. Leveraging advanced AI, TWWAF aims to surpass Vision 2030's objectives, ensuring a safer, more convenient, and spiritually enriching pilgrimage journey.

Literature Review:

Recent literature explores advancements in autonomous wheelchair development, with a 2023 study proposing a fusion of the fuzzy potential method and model predictive control for effective obstacle avoidance in electric wheelchairs. This approach, validated through simulations and real-time experiments, incorporates Monte Carlo optimization for global search and trajectory flexibility[2]. Another notable piece introduces a self-paced P300-based brain-computer interface (BCI) for brain-controlled wheelchairs (BCWs), addressing reliability issues and user workload. Demonstrating driving accuracy exceeding 99%, experiments in realistic office environments highlight the efficacy of this approach. [3] Additionally, a 2020 review emphasizes the "mobility challenge" for individuals with walking difficulties, focusing on the need for affordable sensing and perception systems for autonomous wheelchairs. The review underscores the significance of a modular platform for testing and deploying deep learning-based algorithms without relying on expensive hardware components [4].

[2] Reference

[3] Reference

[4] Reference

Data Description and Structure:

Data Collection for Tawaf and Sa'i Model:

The data collection process for the Tawaf and Sa'i model involved manual efforts, indicating that the data was gathered through methods such as capturing images using cameras. The dataset comprises 7000 images for both Tawaf and Sa'i, reflecting various instances and variations of these rituals. Notably, all images are in grayscale, signifying that they lack color information and consist solely of shades of gray. Each image is standardized to dimensions of 240 pixels by 180 pixels, ensuring a consistent resolution across the dataset. This meticulous data collection approach provides a diverse and well-defined foundation for training and developing the Tawaf and Sa'i model.

	img	steering	throttle
0	IMG/Image_1700563988831793.jpg	0.0	0.0
1	IMG/Image_1700563988931388.jpg	0.0	0.0
2	IMG/Image_1700563988946042.jpg	0.0	0.0
3	IMG/Image_1700563988958191.jpg	0.0	0.0
4	IMG/Image_1700563988969902.jpg	0.0	0.0
5	IMG/Image_1700563988989623.jpg	0.0	0.0
6	IMG/Image_1700563989022789.jpg	0.0	0.0
7	IMG/Image_1700563989055552.jpg	0.0	0.0
8	IMG/Image_1700563989091018.jpg	0.0	0.0
9	IMG/Image_170056398912387.jpg	0.0	0.0

Data Description and Structure:

Data Collection for Object Detection Model:

The dataset for object detection consists of 4400 images, encompassing a diverse range of angles and perspectives. These images are systematically categorized into four distinct classes:

- المطاف (Tawaf),
- الصفا والمروة (Safa and Marwah),
- ماء زمزم (Zamzam water),
- المواضئ (Mawadhe').

To facilitate accurate training and analysis, each image within the dataset has undergone meticulous manual labeling. This labeling process involves the manual annotation of objects, indicating their presence and precise locations within the images, ensuring a robust foundation for the object detection model's development and performance.

1,100 Images 1,100 Images 1,100 Images 1,100 Images

المواضئ ماء زمزم الصفا والمروة المطاف

Methodology

Model Development:

1-Behavioral Cloning for Autonomous Wheelchair:

The methodology employed in this project is centered around Behavioral Cloning, a technique wherein machine learning models are trained to replicate human behavior. Originating from Nvidia, Behavioral Cloning has found application in various domains such as self-driving cars and robots.

2-Transfer Learning with MobileNetV2:

To enhance the efficiency of our autonomous wheelchair, transfer learning was applied using the MobileNetV2 architecture. Despite achieving a mean squared error (MSE) of 0.14, MobileNetV2 was deemed suitable but not utilized due to the stringent performance demands of our real-time processing requirements. The decision was made to prioritize speed performance, leading to the implementation of the first model.

3-Object Detection Model:

Subsequently, we incorporated a pre-trained MobileNet-V2 for object detection, enhancing our model's ability to perceive and respond to the environment effectively.

Data Summary:

- Total Images: 4,400
- Training Images: 3,520
- Validation Images: 440
- Tested Images: 440

Model Evaluation:

- Our model demonstrated a commendable mean Average Precision (mAP) of 74.36%, underscoring its efficacy in accurately detecting and navigating within the wheelchair's surroundings.

Discussion and Results:

Discussion:

The primary goal of this project was to address the specific challenge outlined in the Problem Statement within the context of Saudi Arabia's Vision 2030 for Hajj and Umrah. The Vision sets ambitious targets, including accommodating 30 million pilgrims, delivering high-quality services, facilitating access to Holy Mosques, and enriching the religious and cultural experience. Our focus was on the segment of the population that faces difficulties in mobility during Hajj or Umrah - the elderly and individuals with special needs.

The existing solutions of manual wheelchairs operated by helpers and self-driven electronic wheelchairs were examined, revealing several challenges. Manual wheelchairs require significant human resources, contributing to congestion and potential risks in the crowded pilgrimage areas. Additionally, the varied skills of operators could result in inconsistent service quality.

Our solution, Twwaf, an AI-based autonomous wheelchair, was conceptualized to address these challenges and enhance the overall experience and safety during Umrah. Twwaf leverages artificial intelligence to provide a reliable and efficient autonomous navigation system, allowing elderly and special needs individuals to navigate the pilgrimage sites with greater ease and autonomy.

Discussion and Results:

Results:

The TWWAF prototype, driven by computer vision algorithms, exhibits promising accuracy in navigating the intricate and crowded spaces of the Alharam during Umrah rituals. Its autonomous features hold the potential to significantly reduce the need for constant human assistance, addressing manpower challenges associated with traditional manual wheelchairs. The ability to navigate autonomously is a crucial aspect of the prototype, offering a solution to enhance the independence and mobility of elderly and special needs pilgrims during Umrah. Additionally, the incorporation of computer vision technologies enables the prototype to understand and respond to specific movements and patterns. The real-time object detection capabilities further enhance safety by allowing the wheelchair to navigate efficiently.

Discussion and Results:

Implications and Significance:

The successful initial implementation of Twwaf aligns with the objectives of Saudi Vision 2030 by incorporating artificial intelligence into the services provided during Hajj and Umrah. By addressing the specific needs of the elderly and individuals with special needs, Twwaf contributes to the vision's overarching goals of delivering high-quality services and enriching the religious and cultural experience for all pilgrims.

Furthermore, Twwaf aligns with the broader Vision 2030 goal of attaining leadership in AI-driven economies, showcasing the Kingdom's commitment to innovation and technological advancement. The positive impact on crowd management and the enhanced experience for a vulnerable demographic demonstrate the potential of AI to address complex challenges in large-scale events.

Limitations and Challenges:

While the results are promising, it is important to acknowledge some of the limitations and challenges encountered during the project. Factors such as problems with the route recognition, poor image quality, and problems in the voice recognition system may pose challenges to the smooth operation of Twwaf. Continuous efforts are required to address these challenges and improve technology to achieve greater effectiveness in diverse Hajj scenarios.

Conclusion and Future Work

1- Expansion Beyond Al-Masjid Al-Haram:

- Apply the project's findings to other religious and cultural sites.

2- NLP for Q&A (Fatwa and Utility Map):

- Strengthen the NLP system for a wider range of queries.
- Implement real-time translation and dynamic updates for fatwas and utility information.

3- Language Inclusivity:

- Extend language support to encompass a multitude of languages, ensuring a truly inclusive user experience.
- Implement a user-friendly interface facilitating easy selection and customization of preferred languages.

4- Interconnections Between Wheelchairs:

- Develop a communication network allowing seamless interaction between multiple wheelchairs.
- Explore features that enable wheelchair users to connect with and communicate effortlessly with one another.

5- Vital Signs System:

- Integrate advanced sensors and AI for comprehensive vital signs monitoring.

6- Anti-collision system:

- An anti-collision system in a self-driving wheelchair is crucial to ensure the safety of the user and those around them.

SDAIA
الهيئة السعودية للبيانات والذكاء الاصطناعي
Saudi Data & AI Authority

أكاديمية طويق
TUWAIQ ACADEMY

Team

SCAN HERE

CLICK HERE

- Rama AlMarzuqi
- Esraa Abdullah
- Anas Almana
- Shoug Alkhalaf
- Ali Aljumah