**Sternheimer Letter of Intent**

**VCU CS 24-311 RovoMapper - Autonomous Terrain Mapping using Wheel-Based Rovers**

To whom it may concern:

Our project is aimed at developing an accurate and novel wheel-based asset management system that can track movement of an asset in real-time without relying on external GPS or user-dependent input. The design behind our product is a real-time localization system application that is product-agnostic with fine detail accuracy that can be implemented in a wide variety of use cases. Our product interprets rotational velocity readings from two (or more) optical rotary encoders placed on individual wheels of the object and extracts information such as distance traveled and relative location using trigonometric transformations and heading calculations. From this information, we can overlay a user interface to track and manage assets in indoor and outdoor environments. Furthermore, we aim to utilize our wheel-based asset management system in conjunction with a SLAM-like layer to map and traverse unknown environments which are inaccessible and/or hazardous to humans.

The innovative nature of our project can be broken into two parts. The first part is to further the development of real-time tracking and management systems for wheel-based objects such as bikes, wheelchairs, and cars based on low-cost optical rotary sensors. Unlike any other localization system, the developed sensing system is based on deploying rotational sensors on the wheels themselves making it more accurate in detecting the distance, speed, and directions of the wheels. The system also works with any type of wheels/objects as well as indoor and outdoor localizations. The second part is to further development in the field of robotics/autonomous mapping such that our system can autonomously traverse unknown environments while also simultaneously creating a detailed map of its surrounding area.

Our project could be used to greatly improve indoor localization for asset management systems in locations such as hospitals, warehouses, and factories. For example, our project could be extraordinarily useful within the medical field, as the effective monitoring of assets such as wheelchairs within hospitals is imperative. Performing the monitoring of such assets autonomously could greatly reduce the amount of the time required for medical professionals to locate and monitor assets. The developed systems could also be utilized in many other applications, such as the monitoring of the dynamics of vehicles for efficiency and safety testing or the autonomous mapping of hazardous environments. For example, our system could be used for mining operations to map the topology of cave systems which are hazardous or inaccessible to humans.

* Tamer Nadeem - Computer Science - Faculty Advisor
* Mallika Lakshminarayan - Computer Science - Project Team Leader
* Luke Unterman - Computer Science - Student Team Member
* Tahshon Holmes - Computer Science - Student Team Member
* Imanol Murillo - Computer Science - Student Team Member

**A summary of the project and its purpose:**

* This project is a continuation of a previous capstone project entitled ‘Real-time Indoor Wheel-Based Asset Localization System.’ The initial purpose of the previous capstone project was to develop an accurate and novel wheel-based asset localization system that can track movement of an asset in real-time without relying on external GPS or user-dependent input. The project team from last year achieved this by attaching two Inertial Measurement Units (IMUs) to the rear-wheels of a wheelchair. In doing this, they could calculate the distance traveled/relative location of the wheelchair using readings from the IMUs (which measure gyroscopic movement and acceleration) via trigonometric transformations and heading calculations. From this information, they overlaid a user interface to track the asset’s changing location.
* The aim of our project, ‘Autonomous Terrain Mapping using Wheel-Based Rovers,’ is to first improve upon a few of the errors identified in the previous capstone project and then to develop an autonomous, smart mapping system utilizing a small, two-wheeled toy car equipped with optical rotational sensors. One of the main problems in the previous capstone project was sensor drift. This occurred as a result of the general inaccuracy in the readings from the previously used Inertial Measurement Units (IMUs) as well as issues in bluetooth communication. To improve upon these readings, we aim to replace the IMUs with more accurate rotary optical encoders and incorporate the encoder readings into the current framework. This should enhance the precision of the wheel rotations and distance computations used to monitor the location of the toy car. After the sensors are replaced, we aim to develop a SLAM-like layer using sensor data to autonomously map the toy car’s surroundings.

**A summary of the innovative nature of the project and/or how it furthers research or development on a particular topic:**

* The previous Capstone project which our project aims to improve upon developed an innovative, novel approach to use wheel-based sensors to track assets, inventory, and/or people in real time. The innovative nature of our project can be broken down into two separate parts. The first part is to further the development of the Indoor Wheel-based Asset Localization System by replacing its IMU sensors with rotary optical sensors to reduce noise and sensor drift and integrate new logic for the optical sensors into our framework. The second part is to further development in the field of robotics/autonomous mapping such that our system can autonomously traverse unknown environments while also simultaneously creating a detailed map of its surrounding area.
* This project is very unique because currently there is not much technology that does accurate indoor localization. Many localization systems use GPS communication to get current/past information. The reason why current systems cant work is because they dont provide accurate indoor localization because their data points are more broad. This results in data that isnt useful to users who want to see localization at a smaller scale.

This project would make a positive impact on a vast number of areas, especially the medical field. Health care workers often spend a lot of their time looking for lost equipment, such as wheelchairs. For example, a nurse could spend 20-60 per shift looking for wheelchairs for patients. This project would enable health care workers to see the current location of the equipment with an accurate mapping of the area. Another example would be mining operations or the exploration of hazardous environments, where obtaining an accurate layout of the terrain or infrastructure is of paramount importance.

Current methods for such tasks often involve deploying human personnel or large, expensive robotic systems, both of which may present significant risk or resource investment. By leveraging the advancements in sensor technology and algorithms for localization and mapping, this project provides a robust solution to such challenges, minimizing human risk and optimizing resource utilization. The system will autonomously traverse an unknown environment, creating a detailed map of the area, and delivering invaluable insights into potentially inaccessible or hazardous regions

….