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Autonomous Control and Navigation of Omni-Drive Vehicle (ODV)

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***Abstract*:** In the field of robotics, the importance of mobile robots is steadily increasing. Due to their freedom of movement, mobile robots are more flexible and can perform more tasks than their conventional fixed counterparts.
In this project, we are planning to design a nonlinear controller for an Omni-directional mobile robot. The robot controller consists of an outer-loop (kinematics) controller and an inner-loop (dynamics) controller. For the purpose of localization a sensor fusion method, which combines the onboard sensor, optical mouse and the vision system data, is employed to provide accurate and reliable robot position and orientation measurements, thereby reducing the wheel slippage induced tracking error. Combination of above method will enable the robot to navigate to the target position with desired orientation.

Keywords: Mobile robot; Nonlinear control; Omni-directional; Sensor fusion; Localization; Navigation.

INTRODUCTION

In this rapidly progressing world of technology, the field of robotics is contributing significantly in every domain of life. Among all type of robots, mobile robots stand out owing to their widespread use and applications. Current applications of mobile robots include domestic and public cleaning, transport of goods in hospitals, factories, ports and warehouses, exploration of inhospitable terrains such as space or oceans, mining, defusing explosives, and performing inspections and security patrols.
A special class of mobile robot is an omnidirectional robot. These robots are designed for 2D planar motion and are capable of translation (x, y) and rotation around their center of gravity (θ), i.e. three degrees of freedom (3 DOF). Unlike conventional vehicles, omnidirectional robots can control each of their DOFs independently.
In order to operate effectively, mobile robots should be able to keep track of their current position (localization), sense their surroundings (perception), be able to generate a path to their destination (path planning) and execute it (navigation) in an efficient manner. To a large extent, this is accomplished through sensing and smart algorithms.
To develop, implement and test different algorithms and sensing techniques, we are planning to build an Omni-directional mobile platform. This test bed will be built with locally available hardware components and designed to be very flexible and easy to program.

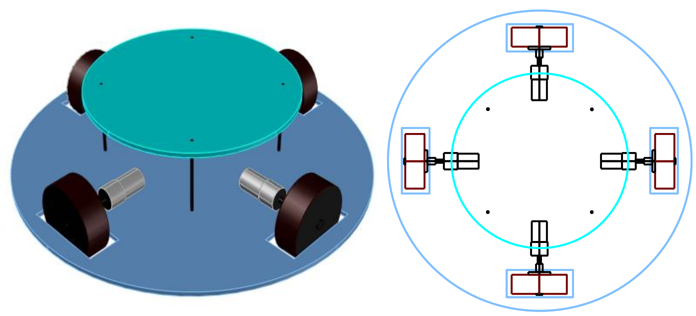

Figure 1: Proposed ODV Model

In this project, the following goals have been set:

- Go-to-Goal: The robot will move to a desired pose according to the target location provided using remote input.
- Reactive Navigation: The robot will navigate to desired location avoiding the obstacle and plan its motion using state machine approach.
- Map-based Navigation: The robot will smartly plan its trajectory based on previously available map, and also update its trajectory as per the dynamically changing environment using vision based SLAM (Simultaneous Localization and Mapping).

TASKS TO BE PERFORMED

1. **Close loop control of PMDC motor**
   - **1.1.** STM32 – ARM Cortex M4 – 32-bit Microcontroller
   - **1.2.** PID and PI control algorithms
   - **1.3.** Voltage control using PWM pulses
   - **1.4.** Feedback using rotory encoders
2. **State estimation of Omnidirectional Robot**
   - **2.1.** Estimation block implemented on RaspberryPi 2
     - **2.1.1.** 900MHz quad-core ARM Cortex-A7 CPU
     - **2.1.2.** 1GB RAM
     - **2.1.3.** Linux Kernel 3.18
   - **2.2.** [x , y , θ] and [V_x , V_y , θ’] estimation using Kalman Filters
   - **2.3.** Pololu MiniIMU v9 for heading angle estimation
   - **2.4.** Rotory encoder or Optical mouse for Position and Velocity estimation
3. **Trajectory planning and Position control**
   - **3.1.** PID and Adaptive Control algorithms
   - **3.2.** Omnidrive model implementation
   - **3.3.** Obstacle avoidance
4. **Image processing and 2-D Mapping**
   - **4.1.** Obstacle detection
   - **4.2.** 2-D Mapping

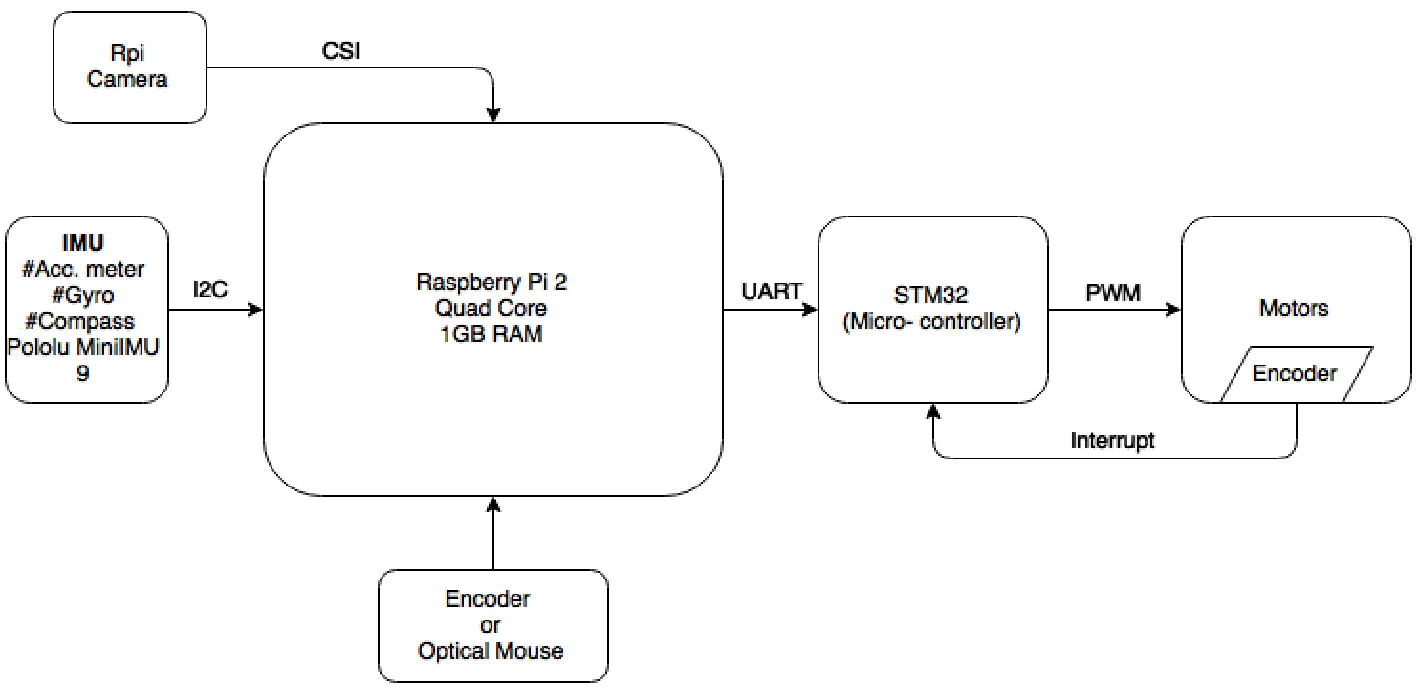

Figure 2 : Proposed hardware schematic

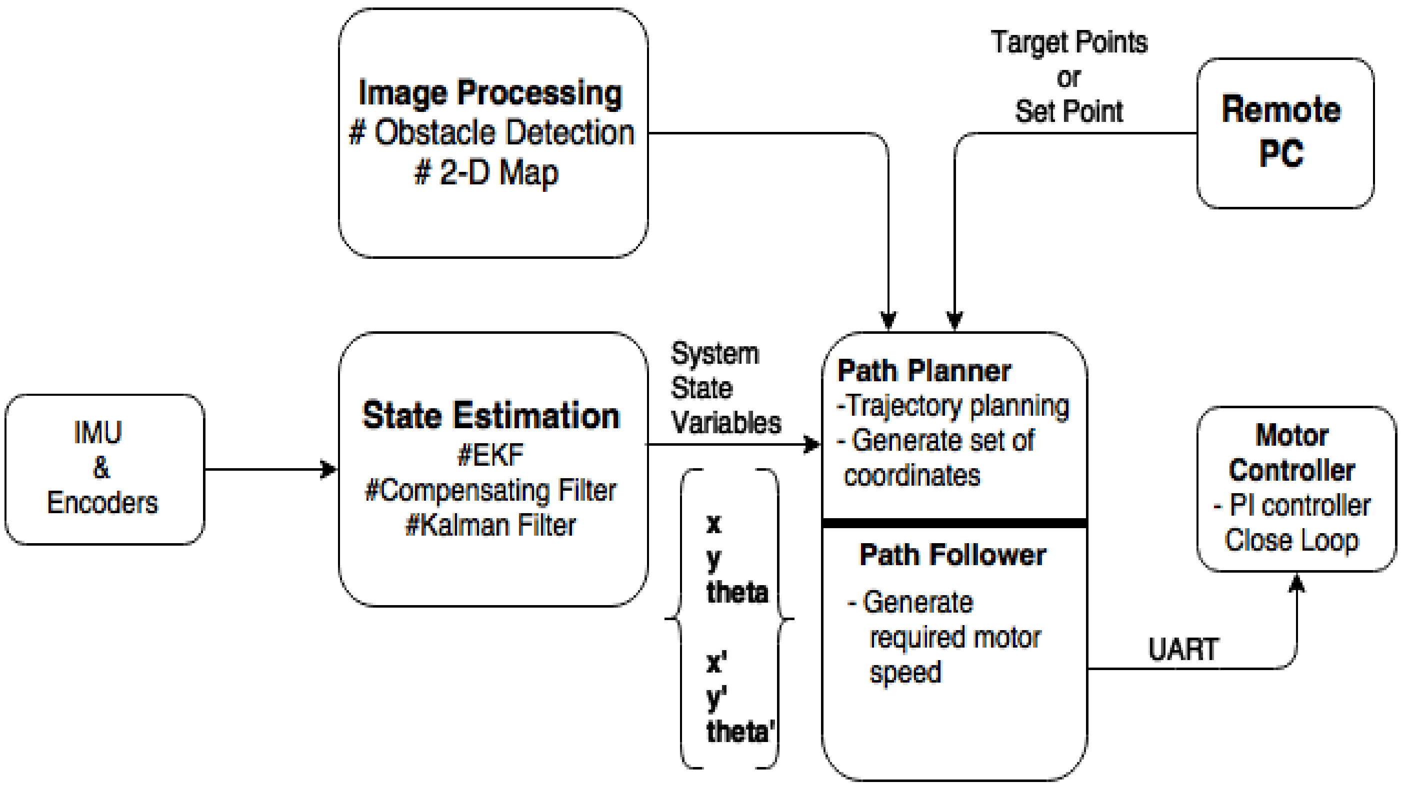

Figure 3: Proposed software architecture

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