**Introduction**

**Mobile Robot & Navigation:**

Hello everyone! Let me start with a question: have you ever seen robots at work in a restaurant or maybe used a cleaning robot at home? These mobile robots are more than just cool gadgets; they have been reshaping many industries greatly. From hospital, factories, to other public areas, mobile robots are becoming essential. But here’s the problem: for those robots to operate safely and efficiently, they need to navigate complex environments filled with obstacles like chairs, tables, and even people. This is where a powerful navigation system comes into play, and that’s exactly what I have been researching.

**Navigation system:**

Think of navigation system as the robot’s version of Google Maps. Traditional systems do a great job in generating a clear path from point A to point B, telling the robots how to avoid static obstacles. But the problem will become more difficult when the environment is dynamic. When there are moving objects like cars, people or pets, fixed paths are no longer safe. Mobile robots need something smarter—a robust system that can quickly adjust to changes in its environment.

**Method**

**An obstacle-avoidance algorithm for dynamic environment:**

So, my research focuses on developing an obstacle-avoidance algorithm for mobile robots in dynamic environment. Unlike traditional system, this approach doesn’t create a fixed path. Instead, it generates motion commands for robots in each time period. In other words, it gives robots moment-to-moment instructions like “turn left” or “move forward”, based on real-time data. Essentially, this method should help the robot develop a kind of “spatial-awareness”, by repeating following three steps: observation, prediction, and decision-making. Let me explain more detail in the following slides.

**Three steps in the method:**

Step1 Observation:

In general, a mobile robot uses sensors like radar, LiDAR, and cameras to scan its surroundings and detect changing in environments. They are similar to people’s eyes and ears. But here’s a challenge: raw sensor data is noisy and unreliable. To tackle this, the system must filter the data to get a cleaner, more accurate picture of surrounding obstacles and their dynamic parameters like position, velocity and acceleration.

In step2, once the robot notices the obstacles, this algorithm will assume they are linear models and estimates their moving patterns based on their dynamic parameters. Therefore, suppose the objects’ movement follow a certain pattern, maybe a straight line or a curve, we can figure out where they will be in a few seconds later. So, we have their potential path, just like a typhoon’s prediction in weather forecasts.

Step3 Making decision:

Now, our system knows where obstacles could be in the future. So, in the final step, we want to find the best motion command for robot to reduce the chance of collision. Nevertheless, this motion should let the robot reach its destination as fast as possible. Because of this, optimization technics was integrated in our method. Just like this picture, the optimization tool can help the robot pick the smartest option to move forward.

**Application on robot:**

To test this navigation system, I applied it to a specific type of mobile robot called General Bicycle Mode or the GBM. The GBM has a unique design. Unlike regular bicycles that steer by turning the front wheel, the GBM has two wheels that can rotate and spin independently. This design allows it to move in any direction without changing its orientation—as you can see in this gif picture! This flexibility makes the GBM highly maneuverable.

**Experiment:**

To see how well this algorithm works, I ran a Python simulation. In the experiments, the GBM had one simple mission: move from point A to point B. Along the way, it encountered obstacles moving in different directions and at different speeds. The robot’s job was to avoid these obstacles and still reach its goal. I also measured how long it took to complete the task to evaluate the system’s efficiency.

Now, here are some assumptions I made for this simulation:

First, everything happens on a flat, two-dimensional plane.

Second, obstacles are perfectly detected. No missed spots

Finally, wheel skidding on the robot was ignored to keep things simple.

**Result**

**Experiment result:**

After testing our navigation system in several scenario, we have two significant results.

First is success rate: our algorithm can bring the robots to it destination successfully in almost every scenario. The passing rate is about 88%, indicating our navigation algorithm is a feasible solution.

Second is efficiency: compared to an existing method, the new system reduced the average travel time by 0.8 seconds. This might not sound like much, but in robotics, small gains in efficiency can lead to big improvements overall.

**Conclusion**

**Contribution:**

Here is why this research matters:

First, it introduces a practical obstacle-avoidance algorithm for dynamic environments, let robots have the ability to evade moving obstacles.

Second, it applies this method to a versatile robot, the GBM, and demonstrates its effectiveness through testing.

Moreover, it allows mobile robots to operate safely and efficiently in complex environment, providing support for logistics, manufacturing or other industries in the future.

**Future works:**

Additionally, there are some works need to be done:

First, the algorithm needs further refinement to improve its success rate. Our goal is to insure the security for both robot and people in same environments.

Second, future simulation should be more complex in order to test our algorithm’s performance. Here is something I can do like adding more obstacles in the simulation environment and let the obstacles’ movement more unpredictable.

Last but not least, this algorithm should pass the ultimate test—implementing this system on a real robot. This could provide critical insights into its real-world performance.

**Final conclusion:**

Thank you for your time! Mobile robots are no longer a vision of the future; they are a present reality, and their impact is growing every day. With improved navigation systems like this one, we’re one step closer to a world where robots can seamlessly and safely assist us in our daily lives.