Localisation System design using ArUco markers

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ABSTRACT

- We Build a localization system using the ArUco Markers of OpenCV
- We calibrated the USB camera and obtained camera parameters by generating the ArUco Board and writing a code snippet for camera calibration
- Prepared the code snippet which allow us to generate any ArUco marker from any dictionary the user want and automatically stores it at the desired location
- Developed a code which detects the ArUco marker from a static and return the marker ID on the terminal. We further extended our work to real-time detection of all the ArUco markers visible
- Further we worked on calculating orientation of the ArUco marker and prepared a code snippet which provide us with the Rotational and Translational vector of marker's position.
- Further we validated our localization system by comparing it from the data recieved from the wheel odometery.

INTRODUCTION

Almost all the robots calculate their position with respect to the starting point using wheel odometry but the position obtained by wheel odometry is not always correct because of various reasons like uneven surface etc. Therefore the marker-based localization system is very important for precise experimentation.
The marker based localization techniques are very useful for the mobile-robot localization.
In our research project we created a marker based localization system using ArUco markers. ArUco markers is a Open Cv based markers with wide range of dictionaries and each dictionary his a wide set of ArUco markers. The algorithm implemented by us is capable of detecting the marker in from static images, videos and is also capable of real-time detection and gives back the ID number of each marker detected and is capable of detecting multiple markers at a time. Furthermore, an algorithm has been developed to provide accurate X, Y, and Z coordinates, along with the orientation of the markers relative to the camera. This algorithm significantly improves localization accuracy and provides valuable information for precise positioning and navigation of mobile robots. • Integrating marker generation, detection, real-time processing, and accurate positioning constitutes a comprehensive solution for mobile robot localization using ArUco markers. The outcomes of this research project contribute to the advancement of robotic systems by enabling them to navigate and localize themselves with increased accuracy and efficiency in diverse environments

METHODOLOGY

1.Marker Generation
- Developed a code to generate ArUco markers of different ID's from different dictionaries by giving the needed parameters.

2. Marker Detection
- Developed a code which enabled us to detect the multiple markers simultaneously and print the marker ID's on the output image as well as on the terminal. Later advanced the algorithm for real-time detection as well as optimized the image size of the input taken by the camera to decrease the time taken for detection

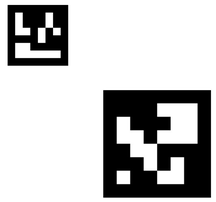
3. ArUco-Board generation & Camera Calibration
- Generated the Aruco-Board which is used in calibrating the camera to obtain the camera parameters which are essential for the orientation calculation of the marker. The camera parameter provided are later in the calculation of the position and orientation of the ArUco marker.

4 Pose Estimation(with respect to Camera)
- Prepared a code snippet which calculated the precise X,Y,Z coordinates of the top-right corner of the marker with respect to camera and also calculated the orientation of the ArUco marker with respect to camera assuming the centre of ArUco marker as origin. This entire pose estimation operations are done in real-time for multiple markers and the X,Y,Z axis of marker which are used for pose estimation are shown in output vedio.

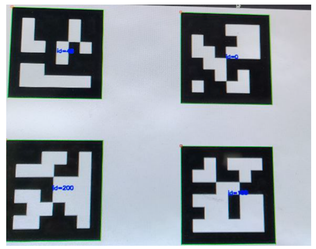
5.Pose Estimation(with respect to ground frame)
- To change the rotational vectors and translational vectors obtained with respect to the camera frames we optimized our code and multiplied the rvecs and tvecs with the predefined rotational vector to obtained them in the ground frame so that the pose calculation frame of wheel odometry and the pose calculation frame of camera are the same.

6.Validating the data
- We validated the position estimation done by the Open-CV using AruCo markers by the position data obtained from the wheel odometry(Assuming robot is running on a plane surface)

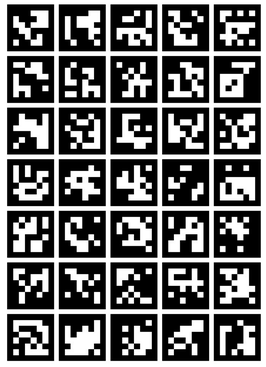
RESULTS



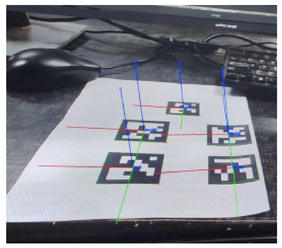
ARUCO MARKERS



ARUCO MARKERS DETECTION



ARUCO BOARD USED FOR CAMERA CALIBRATION



ARUCO MARKERS POSE ESTIMATION

CONCLUSION

In conclusion, our research project focused on mobile robot localization using ArUco markers. We successfully developed a code snippet that generates customized ArUco markers based on user preferences, allowing for the creation of markers tailored to specific application requirements. Additionally, we implemented a robust C++ code for detecting ArUco markers in images or videos, providing accurate ID numbers and the coordinates of the top-left corner of each marker. The system was extended to support real-time processing using a USB camera, enabling immediate localization feedback. Our advanced algorithm accurately determined the position and orientation of detected ArUco markers, providing precise X, Y, and Z coordinates and orientation relative to the camera. Through extensive experimental evaluation, we demonstrated the effectiveness and accuracy of our system, showcasing its potential for practical applications in mobile robot navigation, mapping, and autonomous operations.

FUTURE POSSIBILITIES

Applications for the system created for localizing mobile robots utilizing ArUco markers include autonomous navigation, mapping, and robot swarm coordination, localisation, industrial automation.
Robots can roam freely, carry out precise tasks, construct maps, coordinate motions within swarms, and improve augmented reality experiences thanks to the precise localization offered by the markers. This technology provides flexible and dependable localization capabilities for a variety of business sectors and academic disciplines.

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