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Comparative Study of AMCL and Wheel Odometry for AMR Localization in a Simulated Warehouse Environment Using Turtlebot
Julian Rafi Pratama, Dr. Yohanes Suyanto, M.I.Kom.
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INTISARI

STUDI PERBANDINGAN AMCL DAN ODOMETRI RODA UNTUK LOKALISASI AMR DI LINGKUNGAN GUDANG YANG DISIMULASIKAN MENGGUNAKAN TURTLEBOT

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Autonomous Mobile Robot (AMR) telah menjadi faktor penting dalam perkembangan otomatisasi gudang, seiring meningkatnya tuntutan sistem untuk beroperasi secara efisien dan andal. Salah satu tantangan utama dalam penerapan AMR terletak pada keandalan sistem pelokalan dalam lingkungan terstruktur, di mana kesalahan kecil dalam estimasi pose dapat berdampak signifikan terhadap kinerja navigasi.

Penelitian ini mengeksplorasi penerapan Adaptive Monte Carlo Localization (AMCL) sebagai metode pelokalan probabilistik dan membandingkannya dengan pendekatan wheel odometry pada robot TurtleBot3 dalam lingkungan gudang yang disimulasikan menggunakan ROS Noetic dan Gazebo. Evaluasi dilakukan dengan mengamati kinerja navigasi robot pada beberapa rute pengujian, termasuk lintasan lurus, persegi, dan zig-zag. Wheel odometry mengandalkan data encoder roda, sedangkan AMCL mengombinasikan informasi odometry, data pemindaian laser, dan peta grid hunian untuk memperkirakan pose robot.

Hasil penelitian menunjukkan bahwa dalam lingkungan simulasi yang teridealisasi, di mana pengukuran encoder roda tidak dipengaruhi oleh noise encoder, selip roda, maupun ketidakrataan permukaan, odometri roda menghasilkan estimasi pose yang lebih akurat dibandingkan Adaptive Monte Carlo Localization (AMCL). Temuan ini menunjukkan bahwa kinerja metode pelokalan sangat dipengaruhi oleh karakteristik lingkungan dan tingkat ketidakpastian sensor, serta menegaskan bahwa keunggulan metode pelokalan probabilistik seperti AMCL tidak selalu muncul dalam kondisi simulasi yang terkendali.

Kata Kunci: Adaptive Monte Carlo Localization (AMCL), Autonomous Mobile Robot(AMR), Robot Localization, Autonomous Navigation

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ABSTRACT

COMPARATIVE STUDY OF AMCL AND WHEEL ODOMETRY FOR AMR LOCALIZATION IN A SIMULATED WAREHOUSE ENVIRONMENT USING TURTLEBOT

by

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Autonomous Mobile Robots (AMRs) have become an important component in the advancement of warehouse automation, as systems are increasingly expected to operate with higher efficiency and reliability. One of the fundamental challenges in AMR deployment lies in the robustness of localization systems within structured environments, where even small pose estimation errors can lead to significant navigation performance degradation.

This research investigates the application of Adaptive Monte Carlo Localization (AMCL) as a probabilistic localization method and compares its performance with wheel odometry using a TurtleBot3 robot in a simulated warehouse environment implemented in ROS Noetic and Gazebo. The evaluation is conducted by observing the robot's navigation performance along several predefined trajectories, including straight, square, and zig-zag paths. While wheel odometry relies solely on wheel encoder measurements, AMCL combines odometry information with laser scan data and a prebuilt occupancy grid map to estimate the robot's pose.

The results indicate that in an idealized simulation environment, where wheel encoder measurements are not affected by simulated encoder noise, wheel slippage, or surface irregularities, wheel odometry produces more accurate pose estimates than AMCL. This finding suggests that localization performance is strongly influenced by environmental conditions and sensor uncertainty, and that the advantages of probabilistic localization methods such as AMCL are not fully realized under controlled, noise-free simulation conditions.

Keywords: Adaptive Monte Carlo Localization (AMCL), Autonomous Mobile Robot(AMR), Robot Localization, Autonomous Navigation