

**IMPLEMENTASI *VISUAL-SIMULTANEOUS LOCALIZATION*
AND MAPPING MENGGUNAKAN ALGORITMA ORB-SLAM2
SEBAGAI SIMULASI NAVIGASI BAGI JEMAAH UMRAH**

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ABSTRAK

IMPLEMENTASI *VISUAL-SIMULTANEOUS LOCALIZATION AND MAPPING* MENGGUNAKAN ALGORITMA ORB-SLAM2 SEBAGAI SIMULASI NAVIGASI BAGI JEMAAH UMRAH

Oleh :

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Pelaksanaan bimbingan manasik umrah konvensional sering kali terkendala oleh minimnya fasilitas praktik spasial yang memadai, sehingga jemaah rentan mengalami disorientasi arah saat berada di Masjidil Haram. Penelitian ini bertujuan untuk mengimplementasikan dan mengevaluasi prototipe simulasi navigasi interaktif tiga dimensi (3D) berbasis algoritma ORB-SLAM2 guna merepresentasikan lingkungan ibadah umrah secara otonom. Metodologi penelitian menggunakan pendekatan eksperimental dengan model pengembangan Waterfall, menerapkan arsitektur terlepas (decoupled architecture) melalui protokol komunikasi UDP socket. Sistem ini mengisolasi mesin komputasi pelacakan visual ORB-SLAM2 di lingkungan Linux Ubuntu dari mesin visualisasi grafis Unity 3D di Windows. Pengujian memanfaatkan dataset sintetis dari lingkungan Digital Twin area Tawaf dan Sa'i. Hasil evaluasi kuantitatif menunjukkan algoritma mampu melakukan pelacakan dengan tingkat Root Mean Square Error (RMSE) untuk Absolute Trajectory Error (ATE) sebesar 2,94 meter pada Tawaf dan 9,26 meter pada Sa'i, serta Relative Pose Error (RPE) sebesar 0,91 meter (Tawaf) dan 1,56 meter (Sa'i). Meskipun sistem monocular rentan terhadap manuver rotasi ekstrem, modul Loop Closing terbukti andal dalam mengoreksi penyimpangan lintasan (drift) secara global. Pengujian fungsionalitas Black Box oleh 18 responden juga mencatatkan tingkat kesesuaian 100% tanpa kendala sistem. Kesimpulannya, integrasi lingkungan simulasi 3D dan ORB-SLAM2 berhasil menghasilkan simulasi navigasi yang representatif, fungsional, dan prosedural sesuai urutan syariat melalui logika State Machine, menjadikannya solusi edukasi gladi resik spasial yang aman dan mandiri bagi calon jemaah.

Kata Kunci : *Visual-SLAM, ORB-SLAM2, Simulasi Navigasi, Umrah, Digital Twin*

ABSTRACT

IMPLEMENTATION OF VISUAL-SIMULTANEOUS LOCALIZATION AND MAPPING USING THE ORB-SLAM2 ALGORITHM AS A NAVIGATION SIMULATION FOR UMRAH PILGRIMS

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Conventional Umrah training often faces limitations in providing adequate spatial practice facilities, which leaves pilgrims prone to experiencing spatial disorientation at Masjidil Haram. This study aims to implement and evaluate a three-dimensional (3D) interactive navigation simulation prototype based on the ORB-SLAM2 algorithm to autonomously represent the Umrah environment. The methodology uses an experimental approach with the Waterfall development model, applying a decoupled architecture via the UDP socket communication protocol. This system isolates the ORB-SLAM2 visual tracking computation engine in the Linux Ubuntu environment from the Unity 3D graphical visualization engine in Windows. The testing utilizes synthetic datasets generated from the Digital Twin environment of the Tawaf and Sa'i areas. Quantitative evaluation results indicate that the algorithm is capable of tracking with a Root Mean Square Error (RMSE) for Absolute Trajectory Error (ATE) of 2.94 meters in Tawaf and 9.26 meters in Sa'i, along with a Relative Pose Error (RPE) of 0.91 meters (Tawaf) and 1.56 meters (Sa'i). Although the monocular system is vulnerable to extreme rotational maneuvers, the Loop Closing module proved highly reliable in globally correcting trajectory drift. Black Box functionality testing involving 18 respondents also recorded a 100% suitability rate without any system constraints. In conclusion, the integration of a 3D simulation environment and ORB-SLAM2 successfully produced a representative, functional, and procedural navigation simulation in accordance with Sharia sequences through State Machine logic, making it a safe and independent spatial rehearsal educational solution for prospective pilgrims.

Keywords : *Visual-SLAM, ORB-SLAM2, Navigation Simulation, Umrah, Digital Twin*