Real-Time Localization Using IMU and GNSS for Autonomous System

Overview:

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Introduction:

- Real-time localization is essential for autonomous navigation, vehicle monitoring, and fleet management.
- GNSS provides accurate global positioning but lacks high-frequency orientation updates.
- IMUs offer fast orientation data (roll, pitch, yaw), but may drift over time.
- This project uses fused data from IMU and GNSS using the Xsens MTi-700 sensor to achieve:
  - Accurate position and orientation tracking.
  - Reliable performance even in challenging environments.
  - A 3D visualization system displays vehicle movement in real time

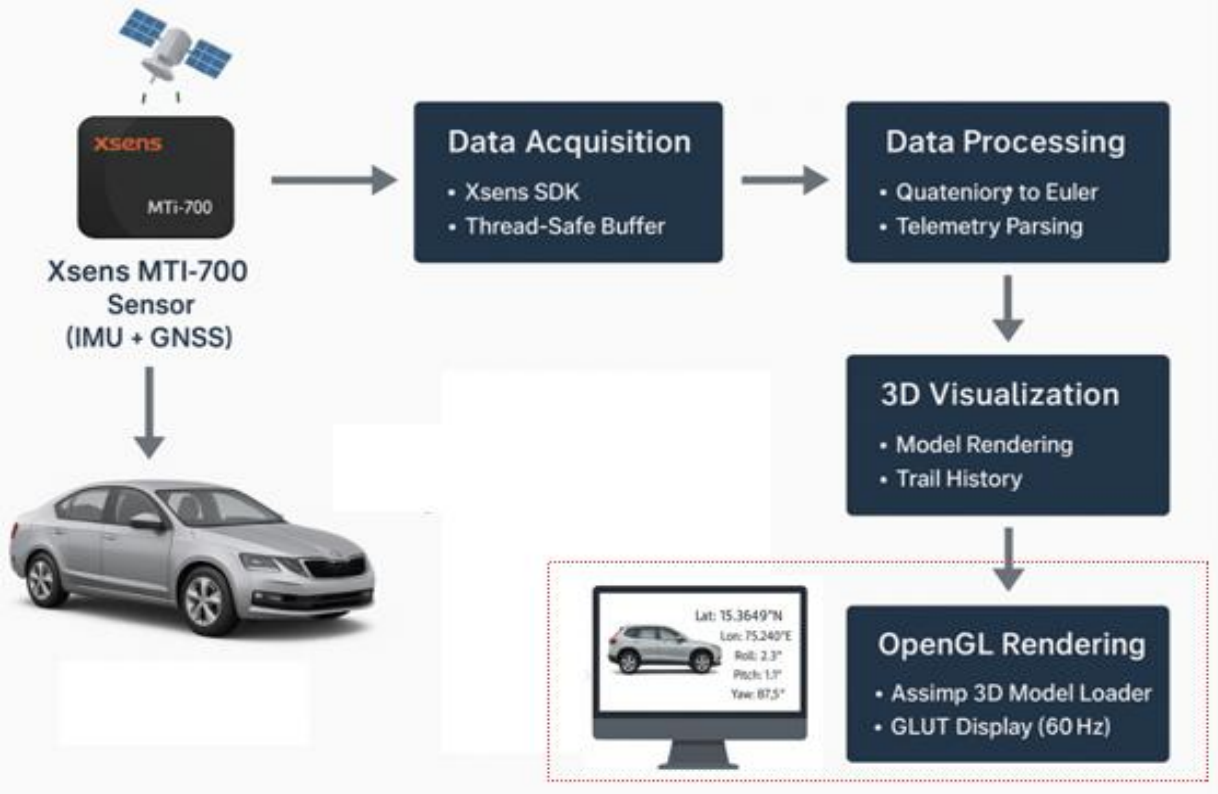
Problem Statement:

Development of reliable System for Real time Localization and Visualization Using Imu and Gnss for Autonomous System.

Objectives:

- Develop a real-time 3D visualization system for GNSS+IMU data
- Render a textured 3D vehicle model with accurate motion and orientation
- Display path trail and real-time telemetry (roll, pitch, yaw, latitude, longitude)
- Implement multithreaded architecture for seamless sensor-to-render synchronization
- Ensure stable performance during continuous sensor updates
- Develop a software architecture that is manageable and expandable, separating data collecting, processing, and visualization

Proposed Methodology :



Tools and Techniques: Software

Programming: C++14

3D Rendering: OpenGL, GLEW, GLUT

3D Model Loading: Assimp

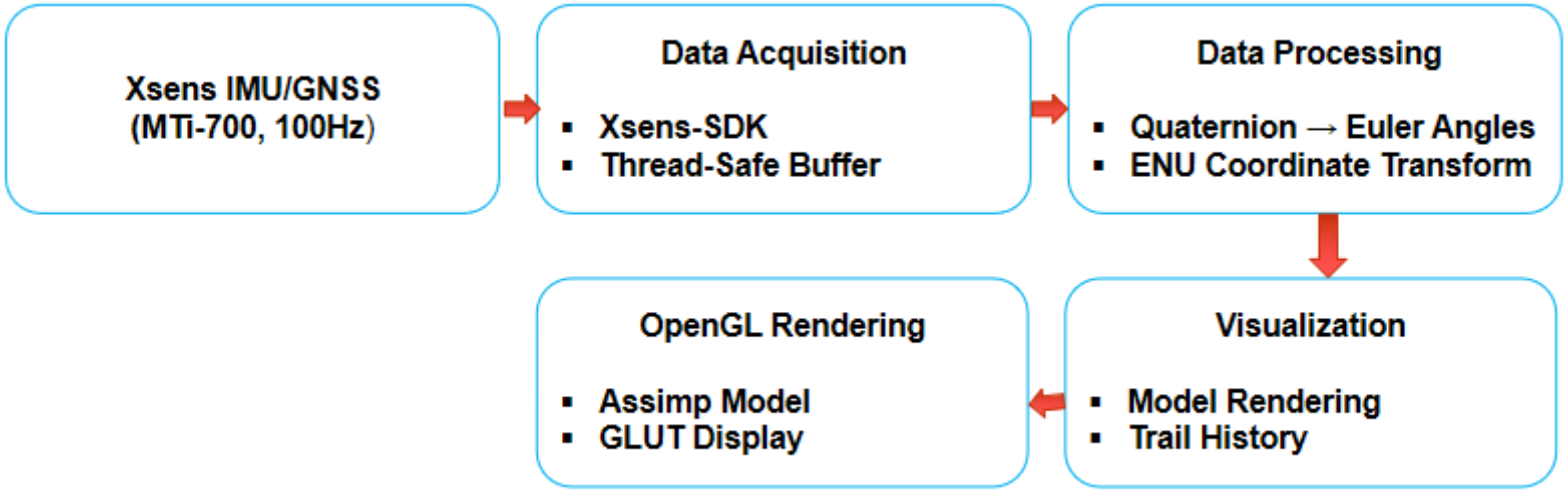
Data Acquisition: Xsens SDK

Data Processing: Haversine Formula, ENU Transformation

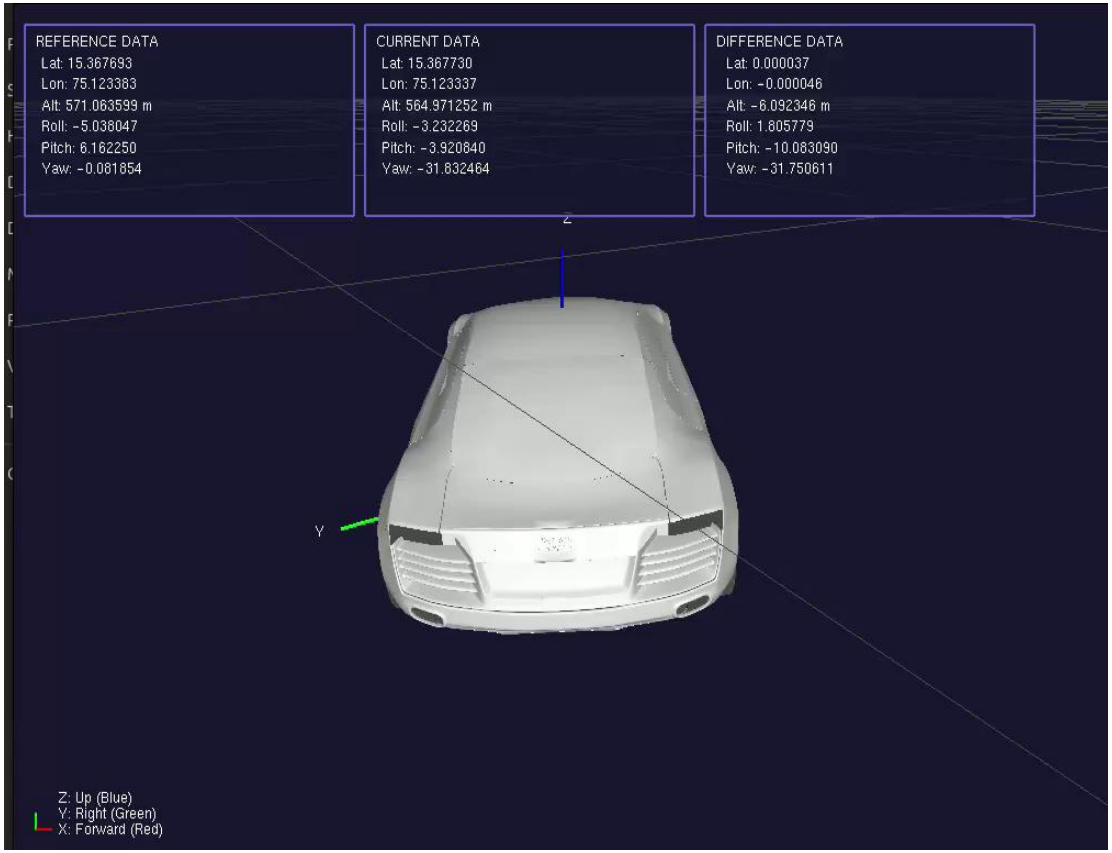
Build System: CMake

OS: Linux (Ubuntu)

Functional Blocks :



Results :


REFERENCE DATA
Lat: 15.367693
Lon: 75.123383
Alt: 571.063599 m
Roll: -5.038047
Pitch: 6.162250
Yaw: -0.081854
CURRENT DATA
Lat: 15.367730
Lon: 75.123337
Alt: 564.971252 m
Roll: -3.232269
Pitch: -3.920840
Yaw: -31.832464
DIFFERENCE DATA
Lat: 0.000037
Lon: -0.000046
Alt: -6.092346 m
Roll: 1.805779
Pitch: -10.083090
Yaw: -31.750611
Z
Y
Z: Up (Blue)
Y: Right (Green)
X: Forward (Red)

Conclusion :

- Successfully developed a real-time 3D localization and visualization system using IMU and GNSS data.
- Achieved sensor data acquisition at 100Hz frequency using the Xsens MTi-700 IMU-GNSS sensor.
- Ensured real-time 3D visualization with end-to-end system latency under 20ms using OpenGL.
- Implemented:
  - Quaternion-to-Euler conversion for accurate orientation tracking (roll, pitch, yaw).
  - WGS84 to ENU transformation using the Haversine formula for precise positioning.
  - A multi-threaded C++14 architecture with mutex-protected buffers for smooth, lossless data flow.

References:

- Xsens SDK Manual – Xsens Technologies, 2021 – xsens.com/manual
- Haversine Formula – R. W. Sinnott, Sky & Telescope, 1984 – movable-type.co.uk
- ENU Transformation – ESA Navipedia – gssc.esa.int/navipedia