# Global 3D Modeling and its Evaluation for Large-Scale Highway Tunnel using Laser Range Sensor

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Precise and accurate 3D model of a road structure is basic information that can be utilized for various purposes, such as safety measures, driving simulation, and reference data for autonomous driving. Generally, the 3D model of a tunnel has been constructed using gyro sensor, however, error accumulation becomes a considerable problem in the case of long tunnels. We tried a method to obtain the most optimal structure of a tunnel by geometric processing: (1) Acquire a set of partial structures by static scanning, and align them by 3D matching using edge feature (2) Fix the absolute position of the data at both ends of the tunnel by GPS and align the rest data again. We modeled the Kanaya Tunnel in Shin-Tomei Expressway, whose length is 4.6 km by this method. The error in lateral direction was up to 0.1% relative to the tunnel length.

**Publication**

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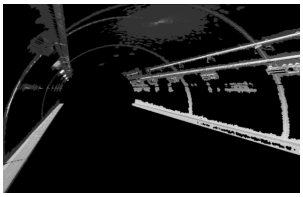
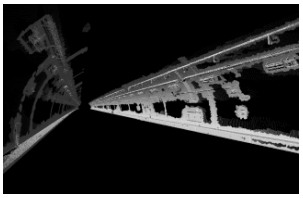
## Scanning


The 3D geometry inside the tunnel is scanned statically (stop-and-go) by every 20m. At the both ends, the scene including GPS antenna is scanned for several times.

## Edge-based Local Alignment

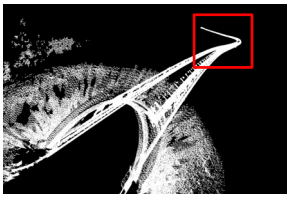
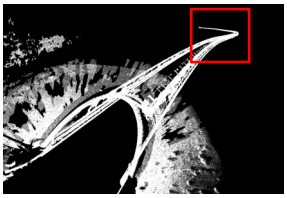



The partial 3D models acquired are locally stitched one-by-one using fast ICP calculation. For dealing with huge data more than 100GB, 3D edge features are extracted and used (reduced by 90%).

## Filling Deficiency


Deficient parts are filled by minimizing a cost function expressing that $z$ values (point depth) become near to the scanned data when it exists, and are smoothly connected with surrounding data.

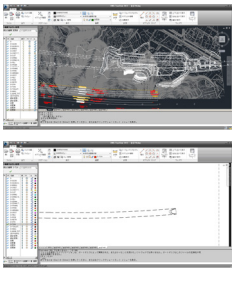
## GPS-based Global Alignment

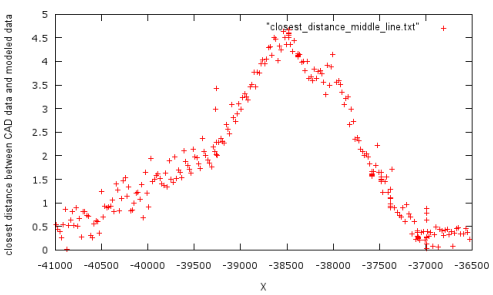



Multiple GPS data can fix absolute position and posture of the 3D models at the both ends. Simultaneous alignment is performed under this constraint kept, for global optimum.

## Result


## Evaluation






The closest distance between the tunnel midlines in 2D CAD data and our 3D data shows the largest difference exists around the central zone, which is no wonder since the error accumulation becomes maximum in the central. The amount is about 4.5 m, just 0.1% of the tunnel length in ratio. The second largest difference exist around $x$ = -38000 to -37700, which roughly correspond to the sharpest curve zone in a tunnel.

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