Place detection through analysis of descriptor sequences of 3D point clouds

ABSTRACT

Place awareness is a critical component of safe decision-making in autonomous mobile robotics. Significance of place detection is more appreciable in large-scale outdoor environment in which, safety measures, mission planning, and responsive intelligent behavior depend on individual circumstances of each specific place. Besides, recall of revisited places assists the generations of loop closure and map merging clues for mapping components of mobile robots in large-scale outdoor exploration missions. In GPS-denied outdoor environment, place identification confronts challenges caused by viewpoint uncertainties, Field of view limitations, and environmental changes. These challenges contribute to inconsistency of feature extraction and feature association in such environment. The place identification methodology presented in this thesis, introduces novel ideas to address all the aforementioned concerns by proper sensing of dense and uniform 3D point clouds, and by incorporation of a non-feature-based descriptor for characterization, which to the best of knowledge was never applied for place detection before. Moreover, this research introduces a new approach for clustering the environment to meaningful and distinct places. A novel procedure for confident identification of revisited places through analysis of sequences and similarity patterns is proposed as well. Experiments using the custom-made sensory system demonstrate the robustness of the methodology in clustering the explored environment to meaningful places, which is attributed to the non-appearance-based characterization. Moreover, the experiments demonstrate highly confident capability of recalling the revisited places and previously experienced scenarios, which is attributed to matching sets of sequences and pattern of similarity values rather than matching a single observation to another.