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# Moving Object Detection for Humanoid Navigation in Cluttered Dynamic Indoor Environments

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***Abstract*-**Humanoid robot perception is challenging compared to perception in other robotic systems. The sensors in a humanoid are in constant state of motion and their pose estimation is affected by the constant motion of the tens of DOFs (Degrees of Freedom) which in turn affect the estimation of the sensed environmental objects. This is especially problematic in highly cluttered dynamic spaces such as indoor office environments. One of the challenges is identifying the presence of all independent moving/dynamic entities such as people walking around the robot. If available, such information would assist humanoids to build better maps and better plan their motions in unstructured confined dynamic environments. This paper presents a moving object detection pipeline based on relative motion and a novel confidence tracking approach that detects point clusters corresponding to independent moving entities around the robot. The detection does not depend on prior knowledge about the target entity. A ground plane removal tool based on voxel grid covariance is used for separating point clusters of objects within the environment. The proposed method was tested using a Velodyne VLP-16 LiDAR and an Intel-T265 IMU mounted on a gimbal-stabilized humanoid head. The experiments show promising results with a real-time computational time complexity.

***Keywords*:** Relative motion, Pose transformation, Confidence tracking, Voxel grid covariance, SLAM