3D Autonomous Humanoid Navigation In Unknown Environments

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Objective

The aim of this project is to make the robot move from the source to the desired goal position in an unknown cluttered environment where the obstacles may be dynamic in nature. We intend to implement the algorithm proposed in [1] and possibly simplify and extend it.

Motivation

The development of the humanoids has been aimed to help humans and possibly replace them in dangerous and redundant work. Possible applications of the humanoids include assisting in daily chores of the humans, delivery of various items, disaster rescue operations, space missions etc. All these and more require the robot to autonomously navigate in unknown environments, detect and avoid obstacles or clutters and (in case of space missions) provide an accurate mapping of the terrain. However, the problem of the navigation of a humanoid is very complex due to constraints on the degrees of freedom, the noises in sensor information and the limitations and error in mechanical movements. Thus there is a need to achieve as error-free navigation as possible.

Proposed Methodology

The proposed algorithm integrates the depth sensing of Kinect along with IMU data and the readings of joint encoders taking the uncertainty in the sensors into account. Earlier methods didn't consider the uncertainty in sensing or relied only on odometry data [2] which could possibly lead to collisions and deviation from the optimal path.

- The task has been divided into the following subtasks, namely- environment mapping, pose estimation and localisation, path planning through motion control of footsteps of Nao and collision avoidance with obstacles.
- A 3D height-map of an unknown environment is created while simultaneously localizing the position of a humanoid in the terrain. The Kinect gives a point cloud which is used to generate the height-map where the data in the height-map is filtered using a state model to reduce the noise.
- The localization is based on pose estimation which uses the input of the inertial sensors (IMU) and the data received through the point cloud (Kinect). The inertial measurements and the readings of the joint encoders provide an estimate of the pose which continuously drifts due to accumulation of errors, so the measurements of the depth data corrects the errors in the estimate. The localization uses the Generalized Iterative Closest Point (GICP) algorithm [3].
- An optimal path is planned in the map generated where shape of the robot and obstacles is taken into account.
- The motion control in the humanoid is achieved using a set of discrete actions where the state of the robot and transitions are defined considering the constraints of the motors and hardware of the robot [4]. The footstep set of the robot is divided into four discrete actions. They are- planar footstep, step-over, parameterized step-onto and step-down.

References

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