REAL-TIME COLLISION AVOIDANCE FOR COMPLEX DYNAMIC SCENES

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Abstract

In robotics, there is an increasing need for dynamic collision avoidance to enable collaboration with humans. We propose a system for real-time path planning for a mobile manipulator, with 3D vision integrated in the control loop. To achieve a short planning time, we rely on extensive preprocessing and GPU parallelization. On a 5 DOF KUKA youBot we achieve an online planning time of 10-15 ms. Collision avoidance with human obstacles has been successfully demonstrated.

Methods

Goal

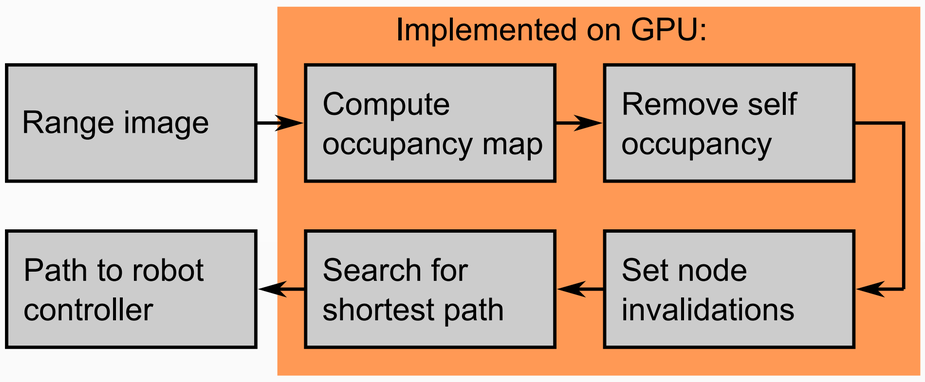
- Find a collision-free movement of the robot arm based on 3D sensor data.

Dynamic roadmaps

- Our approach: Dynamic Roadmaps (DRM) [1] [2].
- Robot arm configurations are represented by nodes in a graph.
- Nearby configurations (nodes) are connected by edges through motion primitives, as in SBPL [3].
- 3D sensor data is used to compute an occupancy map.
- Nodes and edges are invalidated dynamically based on the current occupancy map.
- A search for the shortest path between nodes in the invalidated graph gives a valid arm movement.

Fast GPU-based implementation

- Extensive preprocessing to achieve fast online path-planning.
- Precompute map from 3D sensor space to the graph, for fast node invalidations.
- Data structures designed for fast execution on the GPU.
- Implemented on the GPU with C++ AMP. All processing done on the GPU, to avoid copying large data structures.



Complete control loop

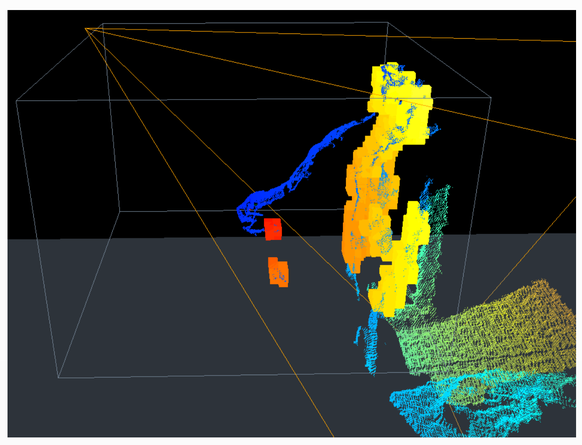
Implementation and Results

- Robot: KUKA youBot (5 degrees-of-freedom arm)
- Workspace: Volume surrounding the reachability of the robot arm, with 3 cm sampling.
- Occupancy map updated with data from Microsoft Kinect (30 Hz).
- GPU: NVIDIA GeForce GTX 680
- Coarse graph of ∼40000 nodes, sufficient for dynamic avoidance.

Results

- Complete cycle performed in 10-15 ms.
- Real-time motion planning successfully demonstrated for the youBot manipulator.
- Also simulated on larger robot (UR5 base + Schunk arm).

Experimental setup with KUKA youBot, Microsoft Kinect 3D sensor and human obstacle.



Self-awareness: Occupancy of the robot arm is continuously removed from the occupancy map.

Dynamic re-planning to avoid human arm. Demo video at [4]

Conclusion

Real-time collision avoidance, as achieved here, facilitates safe human-robot interaction and use of robots in new environments. It also enables mobility, and we are currently working on integration of the robot base to perform simultaneous base and arm planning.

References

[1] T. Kunz, U. Reise. Real-Time Path Planning for a Robot Arm in Changing Environments, in *IROS'10*, 2010

[2] P. Leven, S. Hutchinson. A Framework for Real-time Path Planning in Changing Environments, in *IJRR*,2002

[3] B. Cohen, S. Chitta. Search-based Planning for Manipulation with Motion Primitives,in *ICRA'10*, 2010

[4] SEAMLESS demo video, `http://youtu.be/xXgUrYHrMaI`