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Intelligent 3D Sensing for Robotic Inspection of Hazardous Facilities

Sreenivas Sukumar, David Page, Andrei Gribok, Andreas Koschan, Mongi Abidi

The University of Tennessee
Imaging, Robotics and Intelligent Systems Lab.
Knoxville, TN 37996, USA
{ssrangan, dpage, agribok, akoschan, abidi}@utk.edu

INTRODUCTION

Robots serve many DOE applications for inspection and surveillance in hard-to-reach hazardous areas. Existing robotic systems have thus far used color cameras for inspection along with laser range finders for path planning and obstacle avoidance. The range finders on the robot do provide us with sufficient information about the scene that we propose to exploit towards threat assessment.

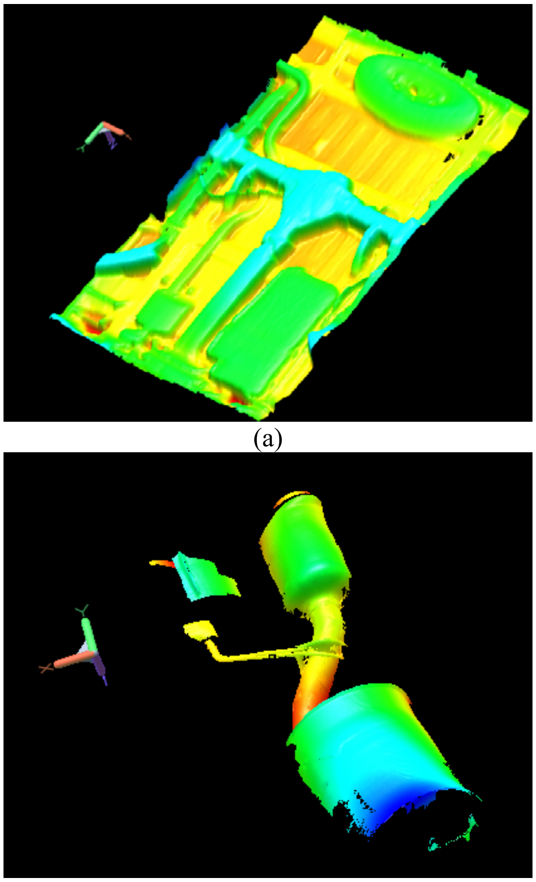
DESCRIPTION OF THE ACTUAL WORK

We have deployed laser scanners on a robotic platform to provide us with high fidelity 3D shape and structure details about a particular scene of interest. In addition to the increased confidence for manual inspection, 3D sensing is not influenced by illumination and lighting as is the case with most other visual surveillance systems. The calibrated spatial data also acts as a visualization bed for monitoring other time-varying physical parameters such as temperature; fluid flow etc. measured using different sensors at the scene of interest.

In Figure 1, we show the 3D scene collected using two different types (time of flight and triangulation) of 3D laser scanners mounted on a mobile platform.

To interpret such a real-world scene represented as a mesh model, we have formulated a surface shape analysis method based on curvature. The mesh is first segmented as smooth patches along sharp edges and regions of high curvedness. Using a simple region growing procedure, we also obtain the patch adjacency information. We then describe each of these patches using our proposed *curvature variation measure (CVM)*. The CVM is the resolution normalized entropy of the Gaussian curvature.

We leverage kernel density estimators towards the computation of the density of curvature. The idea is to output the real world scene as a graph network of patches with our CVM at the nodes describing the patch complexity. With prior knowledge, about the components, the scene understanding reduces to the problem of comparing patches with similar CVM's.



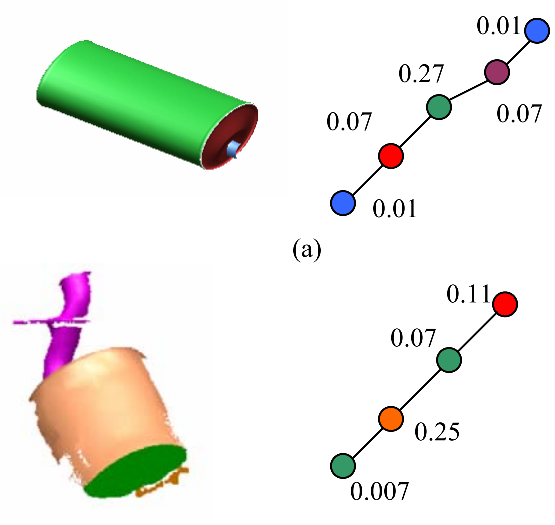
(a)

(b)

Figure 1: (a) Mesh rendering of the data from the time-of-flight system with an accuracy of 10-15 centimeters within a radius of 8m. (b) Mesh rendering of the data from the triangulation-based system with an accuracy of 2-3 centimeters.

RESULTS

We show some results in Figure 2, where we demonstrate the graph description of the coolant from Figure 1(b).



(a)

(b)

Figure 2: Symbolic graph description using the CVM.(a) Segmented object in its CAD form. (b) Segmented object from the scene.

CONCLUSIONS AND FUTURE WORK

With the data acquisition, we have made certain assumptions about the smoothness and linearity of the trajectory of the robotic platform. In future, we will focus on relaxing our constraints on the motion of the robot.

On the data from the robot we have implemented a paradigm that uses part (region) relationships from a geometric definition of an object to a more symbolic representation. We would like to perform rigorous experiments on partial graph matching for scene analysis and inspection using a model based strategy before we claim confidence and robustness. We also would like to experiment the effect of segmentation on our algorithm.

ACKNOWLEDGEMENTS

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