論 文 の 内 容 の 要 旨

論文題目：

Research and Development of a Tiny TOF Laser Line Sensor System for Task-Oriented Robotic Applications Based on Active Local Sensing

（能動局所センシングに基づくタスク指向ロボット応用のための小型TOFレーザラインセンサシステムの研究開発）

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In a lot of real world robotic tasks, the perceptual incompleteness limits the effectiveness of robot agent systems when encountering a complex world environment with uncertainty. The appearance of powerful sensors and scene understanding approaches greatly enhanced the robot perception from several levels in recent years. However, the robot perception is still awkward because the perception hardware and software are not flexible and customizable when handling different tasks.

This dissertation addresses this very prevalent issue on robotics research and proposed our novel systems and approaches. There are basically two methodologies to handle the incomplete perception problem, enhance the sensing ability and equip reasoning ability. To improve the sensing flexibility, we design a tiny TOF laser line sensor which can be flexibly installed on any part of the robot for multi-purpose applications. We also discover that by providing some prior of the real-world knowledge like functionality, geometry and physics, we can design a reasoning vision cognition framework to make a guess of environment even without direct observation and then verify the recognition results using our tiny sensor. The lightweight flexible, customizable and robust features of the tiny laser line sensor are demonstrated in several active local sensing based task-oriented robotic applications.

A novel lightweight tiny laser line range sensor system based on the Time-of-Flight (TOF) principle is developed. Attribute to the delicate circuit design and optical attachments, the sensor is as small as 35[mm]×27[mm]×30[mm] and less than 20[g]

while achieve 256 line effective pixels under a single measurement with a range of 0.05[m] - 2[m]. A higher measurement rate(60 - 100[Hz]) can be achieved in short range application. We model the overall errors of the sensor and formulate calibration methods, achieving repeatable accuracy and measurement bias both within 2[cm] with our tested ambient lighting conditions and measurement ranges.

The active local verification with reasoning based vision approach is demonstrated through the application of agricultural tomato harvesting task. The difficult lies in detecting the pedicel of each tomato which is very small and cluttered. On the vision side, we consider a simple fact that with respect to the gravity and interaction forces, every tomato remains stable due to the physics rules. According to this assumption, a probabilistic model is created and the picking order in the branch is assigned under the evaluated geometrical structure. Given the guesses, we apply the tiny laser sensor to verify and detect where the pedicel is through local sensing.

The task-oriented robotic applications of metallic tools grasping and multi-link aerial robot manipulation using tiny laser line sensor are documented. We developed a reflectance guide local sensing framework using the customized tiny laser sensor output to align the robot end-effector to the tools with metallic surface of high reflectance to achieve grasping. For aerial robot application, the multi-link aerial robot whole-body object manipulation application using multiple tiny laser sensor system is illustrated. The tiny size, lightweight and as well as multiple sensors operation framework demonstrated the feasibility and effectiveness of this difficult robotic application.