Title	螺旋軌道を用いた二次元および三次元測位装置の開発
Author(s)	野口，尚人
Citation	
Issue Date	2012-03
Type	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/10428
Rights	
Description	Supervisor:丁　洛榮，情報科学研究科，修士

Development of an Integrated 2D and 3D Location Measurement System Using Spiral Motion Positioner

Naoto Noguchi (1010047)

School of Information Science,
Japan Advanced Institute of Science and Technology

February 6, 2012

Keywords: three dimension location measurement, spiral motion, two dimension, sensor.

Advances in technology and manufacturing have created various types of location measurement systems that can be used for robotics, security and surveillance systems, and so on. Most existing sensors have been designed to measure the distance in the same flat plane. However, current robot applications are expanding rapidly from the flat surface to a wide range of terrestrial, airborne, and undersea environments. Recently, such attention has been paid to developing different types of mobile robots such as flying robot, swimming robot, or jumping robot that can be operate in large three dimensional environments. Therefore, the objective of my thesis is to develop a cost effective and energy efficient three dimensional location measurement system that can be incorporated into a wide range of mobile robot platforms in the areas of distributed robotics and security and surveillance.

There have been considerable efforts to secure wide-ranging observations for three dimensional location measurement systems which have been implemented in different ways such as pan-and-tilt positioner and Laser Radar (LADAR). The pan-and-tilt mechanism enables sensor beams to sweep up and down and to the left and right at various angles by generating two independent rotation motions with respect to a vertical axis and a horizontal axis, respectively. A wide range of sensors mounted onto the pan-and-tilt positioner has been applied to surveillance, SLAM, grasping, and robotic eye mechanism. However, the overall system tends to become heavy and bulky. Similarly, three dimensional laser scanners have been recently proposed by combining a tilting motion and Hokuyo LRF. However, several questions remain as to how the difference between latitude and longitude resolutions and substantial blind spots can be resolved. On the other hand, LADAR employs the same operation principle like radars and light from laser beams. Through analysis of the pulsed laser light reflected from objects, LADAR can obtain the positions, velocities, and other geometric features of objects. Due to its capability to observe large spaces with very high precision, LADAR has a large number of applications in geography and atmospheric physics, industrial systems, and robotics. However, LADAR turns out to be a very complicated system, as it needs additional optical components such as mirror, photo-detector, and receiver electronics.

In the most fundamental sense, one simple and easy-to-implement idea for three dimensional sensing is to mount existing sensors developed for two dimensional applications onto a three dimensional positioner. Along the lines of this idea, my thesis presents a novel three dimensional positioner enabling two dimensional range sensors to measure the distance to objects in all directions without blind spots. The main features of the positioner are summarized as follows: 1) a simple nut-and-bolt and link mechanism; 2) continuous spiral trajectories; and 3) a single motor driven system that helps reduce the size, weight, mechanical complexity, and cost. Moreover, I effectively integrate two dimensional and three dimensional positioning functions in my thesis.

The three dimensional positioner consists of the following four components: motor drive, gantry, rotation device, and function device. The motor drive generating the rotation motion of 0.72 degree per one motor step includes one Tamagawa Seiki SP5423-2AA0 stepper motor, a motor driver, and a gear. The gantry part consisting of a motor container and a stud bolt with a 4 mm pitch is to support the superstructure of the positioner. The rotation device includes a crank, a link rod, a base board, a flange, a ball bearing, and a gear from the top down to the bottom. The crank, the link rod, and the base board are fabricated using Nippon Polypenco MC901

MC nylon. Various types of sensors can be mounted onto the distal end of the rotation device. Specifically, the motion of the crank in the positioner represents a spiral pattern along the thread of the stud bolt. The function device represents a spiral pattern according to the thread of the stud bolt. It should be emphasized that the dimension selector determines either two or three dimensional range observations. The function device is composed of the dimension selector made from the same MC nylon and a flange nut.

Next, from the standpoint of the overall control schematic, the Atmel AVR ATmega328P microcontroller is used to control rotation motions by the stepper motor and to feed measured data to an outside component through a communication link. Here, the measured data is two-fold. One is the motor feedback data, and the other is the sensor measurement data. Meanwhile, the controller forwards the control signals of both the step and direction to the motor driver. The direction signal sets the direction of rotation and each pulse on the step signal causes the controller to rotate the motor one step in that direction. The rotor position of the motor is fed to the controller. Further details on transformation between 2D and 3D observation will be explained in my thesis.

To demonstrate the validity and effectiveness of the proposed 3D sensor positioner, I performed simulations to examine how the positioner generates desired spiral motions, and how all the possible combinations of individual parts affect the effective sensing range. The dynamic simulation model of the positioner is created with SolidWorks and incorporated into the well-known multi-body dynamics analysis software RecurDyn. Next, to examine the positioner's motion accuracy according to different operation modes, 3D, 2D, and transformation between 2D and 3D functions were tested. From the results, I can confirm that 1) the positioner performs a continuous motion that allows sensor beams to scan the surface area of the upper hemisphere, 2) the overall integration of the positioner system and its controller can be considered quite satisfactory for continuous observation operations, and 3) the proposed positioner can provide robots with an efficient, fully adaptive sensing scheme. Specifically, I should emphasize that these various positioner functions were realized through a single motor. As my future studies, I will perform the design optimization of link length in order to minimize the positioner size while providing desired sensor beam coverage. I will then develop recognition algorithms for different sensors corresponding to the positioner trajectory, and install the sensor positioner system into a mobile robot platform to evaluate their performance in real-world conditions.