Visual Servo Control of Mobile Manipulator

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In this thesis, we consider a visual servo control problem of mobile manipulator(we call visual servo control mobile manipulator as robot with integrated locomotion and manipulator in future). We propose a control method for very useful the mobile manipulator of end-effector mounted the camera to position a robot arm.

The robot manipulator and the mobile robot has been developed from request of industrial society as automation production. Construct of line of a factory becomes only a few of a limit from moving the robot manipulator and easy alteration of line. But, work as moved is hard. Because work point motion make a wrong forecast of unexpected motion than work such as no mobile manipulator. Visual feedback can help overcome it problem, because a vision sensor is a non-contact and can provide information on a much larger area of the work-cell than a force sensor provides. Hence it is necessary to the mobile robot mounted the robot manipulator mounted the robot manipulator of end-effector mounted camera to position a robot arm.

The previous researches is described in the pages that follow.

- There is researches which incorporated into the manipulability measures for singularity avoidance and controlled position and orientation.
- There is researches using vision system later moving for regulation.
- There is researches which control the pose of the control object that incorporated with mobile robot, robot manipulator and camera.

But, we found that in the above the previous researches the use of camera and the mobile structure mounted the robot manipulator dose not always give good performer. It dose not transact it information with vision system is expected target motion. When a manipulator encounters a kinematic singularity during Cartesian motion, the visual servo

system will fail. To cope with contrary to expectation motion, when visually servo a target with a robot with integrated locomotion and manipulator, it is also important that the robot manipulator maintains a configuration that allows motion in all directions of possible target motion without requiring extremely large joint velocity from any actuator, because the future motion of the target may include imprecisely known. This also requires that the robot manipulator should not be near singularities. Typically, when visual servo targets with a robot with integrated locomotion and manipulator it is necessary to constrain the allowable visual servo regions of the workspace where there no danger that the manipulator passes near kinematic singularities.

Hence, In this thesis, we consider a visual servo control of mobile manipulator. The mobile manipulator mounted the robot manipulator of end-effector mounted camera to position a robot arm, and we consider visual servo is to use visual information to control the pose of the robot's end-effector relative to a target object or a set of target features. We consider redundant robot manipulator with respect to kinematics from the mobile robot mounted the robot manipulator. Hence the mobile robot, the robot manipulator and camera shall regard one object that it control consider. A control subject is behavior at the same time with respect to the mobile robot, the robot manipulator and camera. Because, visual servo can apply any time as always moved a target. In addition, for make use of fully merit of the mobile robot mounted the robot manipulator, it add an idea of the manipulability measure. An arm pose decides with valuation function used manipulability measure so that is kept an optimal arm pose, or the robot manipulator performs control of singularity avoidance. And, When we consider modeling robot with integrated locomotion and manipulator, each motion of mobile parts, robot manipulator parts and camera part give consideration with respect to mutual motion give influence. And, we must verify a proper technique with respect to visual servo of the the mobile robot mounted the robot manipulator with simulation with reference to velocity level control. These are a purpose of this thesis.

We defined several functions for modeling the robot with integrated locomotion and manipulator.

- A function of mobile robot changes the wheel velocity into the mobile robot velocity.
- A function of robot manipulator changes the joint velocity into the Cartesian velocity
- A function of camera changes the Cartesian velocity into the feature velocity

A function giving above functions changes the joint velocity into the feature velocity is a combination each function of { robot manipulator+camera }, { mobile structure+camera }, { mobile structure+robot manipulator }. But, It function adds to terms consider a mutual relationship.

The mobile robot, in this thesis, has 2 fixed wheels(drive wheels) on the same axle and 1 castor wheel(2DW1C), is the autonomous mobile manipulator moving in the x-y horizontal plane. An arbitrary inertial base frame Σ_w is fixed in the plane of motion, while a frame Σ_v is attached to the mobile robot. A moving direction is y axis. A frame of the robot manipulator is same mobile robot frame Σ_v. Camera mounted the robot manipulator of end-effector, it is a camera frame Σ_c.

A target move same horizontal plane which is mobile manipulator moving in the x-y horizontal plane, provided a target is carry conveyor belts and a target velocity is known. This thesis introduce furthermore to idea of the manipulability measure used to aid in visual servo, and it provide so that the robot manipulator maintains a configuration that allows motion in all directions of possible target motion with respect to unexpected motion and unknown environment, namely, it performs singularity avoidance.

In this thesis, a control method uses dynamic look-and-move system. This control architecture is hierarchical and uses the vision system to provide set-point inputs to the joint-level controller. Nearly all implemented system adopt the dynamic look-and-move approach. For reasons, Firstly, the relatively low sampling rates available from vision make direct control of a robot end-effector with complex, nonlinear dynamics an extremely challenging control problem. Using internal feedback with a high sampling rate generally presents the visual controller with idealized axis dynamics. Secondly, many robots already have an interface for accepting Cartesian velocity or incremental position commands. This simplifies the construction of the visual servo system, and also makes the methods more portable. Thirdly, look-and-move separates the kinematic singularities of the mechanism from the visual controller, allowing the robot to be considered as an ideal Cartesian motion device. Since many resolved rate controllers have specialized mechanisms for dealing with kinematic singularities, the system design is again greatly simplified.

As a result of this thesis, robot with integrated locomotion and manipulator is derived by a model from a function giving in consideration of effect with respect to each motion. We proposed a control method in consideration of manipulability measure, and performed simulation of visual servo in consideration of manipulability measure for it confirm appropriateness. As a consequence, robot with integrated locomotion and manipulator in consideration of manipulability measure has vast work space and a configuration that allows motion in all direction of possible target motion. Hence we proposed visual servo of robot with integrated locomotion and manipulator considers useful than usual visual servo. And, again, it is fully appropriate system with reference to velocity level control.