REAL TIME SIMULATOR FOR FIELD SURVEY MOBILE ROBOT

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ABSTRACT

A systematizing elucidation to the hazards present in the current human health due to spraying of conceivable toxic chemicals in the detained space of an agricultural field or hot and steamy glasshouse is accomplished by the design and disposition of a sovereign mobile robot for use in disease prevention and pest control applications in monetary greenhouses. An Embedded system based stereotyped robot is designed for this purpose. The platforms ability to fortunately head out for itself down the platform of a greenhouse shows the forcefulness of this platform, while the pesticide sprinkling system is used to efficiently spray the plants evenly with set dosages. A vision based robotic control regulation strategy is developed for a non-calibrated camera system which is mounted on a wheeled single mobile robot contingent on non-holonomic motion restraint, which can drive the mobile robot to the target position with exponential convergence. Subsequently, by using the retrieved camera intrinsic parameters, a straight-line motion controller is developed to drive the robot to the desired position, with the coordination of the robot always facing the target position. By the proposed method, the robot can be confined in map-free and GPS-free environments, and the results of localization can be theoretically proved confluent to their real values and thriving to the measurement noises. The performance of the proposed method is further validated by both simulation and experimental results.

Keywords – Sovereign mobile robot, non-holonomic motion, based articulation controller, vision based control localization, pesticide spraying system and non-calibrated camera system.

I. INTRODUCTION:

Nowadays, the growing demands of applications in the micro field lead to design and development of complex micro tools to indulge for such needs. These micro tools can only be agglomerated by all kinds of micro/Nano-positioning and engrossing devices under the observance of the microscope [1-5]. Micro/nano assembly refers to assembling of all kinds of micro/ nano parts for human integrated micro device for operating complex tasks in micro/nano environment, which is immense or impossible to achieve usually by designer/human hands. These micro parts refer to actuators, sensors and structures, which are developed for massive applications in the aerospace engineering, biomedical field, automotive engineering, communication, and IT industry. The micro assembly process can be classified into semi-automatic assembly, self-assembly, and robot based automatic assembly. In the case of self-assembly, chemical bonds and physical phenomena such as mechanical, electrostatic, etc. and chemical bonds can be used to stick various components with various contacting surfaces. A robotic based assembly system is constituting of a gripping device, micro positioning stage, and a microscope based digital visual image processing system, which can be used to determinate, reach and operate some or many micro objects. The micro/nano assembly process can be sub-divided into a set of series basic tasks that are perceptibly performed: detecting the micro/ nano parts, positioning the gripper, enthralling the micro part, arousing the micro part, and untie the micro part. The differential drive or heliograph drive mobile robots are subject to non-holonomic restraints, and their path tracking control is challenging because there exists no smooth time-invariant feedback controller [1, 2]. Various model-based control methods, including discontinuous controllers [3], time-varying controllers [4, 5], and hybrid controllers [6], have been developed. Agricultural wheeled robots involve automatic and meticulous control of moving various parts such as wheel's speed and steering. The design and development challenges of a control system in this gaze are the response, shorter settling time, over-shoot, and smaller steady state error. Automatic guided devices have become an important part in different demeanour of today's mod-ern agriculture and precision farming. With the technologies in controls theory, application of mobile whee-led robots in agriculture has shown growing upcoming interest towards automation. Such applications include spraying of chemicals for fungicide, monitoring of crops, data collection from the field, etc. An autonomous wheeled mobile robot for use in scourge control and malady deterrence application for a financial greenhouse has been represented wherever human health hazards are concerned in spraying conceivable cyanogenic chemicals during a confined area. Another mobile automaton for autonomous de-leafing method of cucumber plant has been studied. varied drive and conveyance techniques are enforced in farm robotic styles. A simplified DC (DC) motor equation has been enforced for the driving mechanism of associate degree agricultural mechanism platform with four wheels steering for weed detection. Most of these pasts researches have focused on a particular, spatially non-varying task that has to be done by the mobile robot system in a field environment, a vast difference between a robot in industries and its implementation with a field robot is the environment impacts in the surroundings. A field robot's platforms and imple-mentations are subjected to an adjustable environment, which means, it can touch, sense or wield the crop and its surroundings in a circumscribed manner which makes it elementary to have minimal amount of impact while increasing precision and efficiency. Hence, an important challenge in this area is the accurate control of the robot driving actuator due to the assessment errors and perturbation during the robot gesture in creak agricultural field which yields to the cumulative effects of the small error. As a result, a larger error in the robot's speed and position will be expected.

A golem could be a mechanical or virtual artificial agent system. In observe, it's ordinarily AN electro-mechanical system that, supported its look or motions, portrays a way that it's intent or algorithmic rule of its own. The word golem will point dead set each mechanical robots and virtual software system agents, however the latter square measure sometimes noted as robots. Throughout the history, folks have tried to form robots, however solely within the twentieth century that technology became advanced enough to form tota-lly autonomous machines with the power to form selections of their own. Today robots are in widespread use in factories for welding, assembling and packing and are beginning to appear at homes too. There is a vast variety of robots helping us in space, space, resea-rch, the battle field and helps scientists in the study of intelligence and learning.

For robotic engineers, (Dec 2003) the external appearance of a machine is much less important than the method its actions are controlled. The high the control system appears to have algorithm of its own, the more the machine is to be called a robot.

II. METHODOLOGY

In this project, we concentrate on multiple mobile robots that autonomously search for the parts of a agricultural field, which are distributed in an unstruck-tured surrounding environment with complex terrain and crop distribution. Once a field of interest is identified and encountered, the mobile robot will attempt to autonomously grasp it and take snapshot it up with its onboard controller using visual servoing, and store it in a designated site for further processing and manipulation. When these mobile robots determine that they have collected all the essential snapshots, they proceed to arrange them to take decision about the configured application, by cooperatively handling the data. In this project, an underlying requirement of the paper is accomplished. Distinctively, the sturdy theme of servo visual management is developed for guiding a mechanism towards a target object, and for autonomous grasping and manipulating the article. The visual controller developed here can integrate the capabilities of the mobile mechanism base, the aboard arm, and also the CCD camera. A Pioneer DX3 mobile mechanism with a 5-DOF aboard arm is employed during this paper, as shown in Fig. 1.

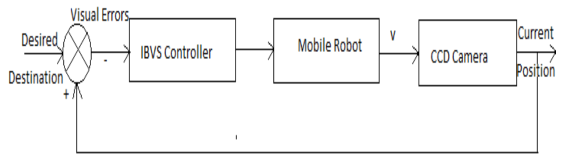

Fig.1 Visual servoing scheme for motion control of WMRs

The mobile mechanism in Fig. one may be a non-holonomic vehicle with 2 drive wheels whose speeds is controlled severally and might be measured victimization the 500-pulse encoders mounted on them. A color CCD camera and a 5-DOF Pioneer Arm square measure Fig. 1. Experimental setup of visual servo management mounted on the mobile mechanism to represent a vision-based mobile manipulation system. The aboard Pioneer Arm may be a 5-DOF mechanism with a gripper consisting of foam-lined fingers for a firm grasp. Driven by six reversible open-loop servomotors, the tip of the closed fingers of the arm features a reach of fifty cm from the middle of the rotating base. The color CCD camera may be a pan–tilt– zoom (PTZ) vision system with 26× optical and 12× digital zoom for a good vary of applications. Additionally, the mechanism comes with Associate in Nursing Active Media Color Chase System (ACTS) color-blob chase code that is utilized to trace the image coordinates of the target object, that in Fig.1 one may be a dentifrice tube with a red cap. Additionally to the Pioneer Arm and also the CCD camera, the mechanism is supplied with Associate in Nursing aboard laptop and diverse sensors, like an optical device distance finder, sonar ring, compass, and a gyro. The aboard machine capa-bility will support period of time performance of the visual servo system.

III. DESIGN OF CONTROLLER:

Unlike the classical visual servo management approach [5], the management theme developed during this paper decouples the management objective between the DOFs of the mobile golem base and therefore the aboard 5-DOF arm. Specifically, the management method is decoupled into 2 steps once the golem AN attempt tries to choose up an object of interest in its field of read. Within the start, by observant the visual Error between this image and therefore the recorded image at the required location and orientation, the mobile golem base makes an attempt to vary its posi-tion and heading by adjusting the angular velocities of its wheels therefore on build the golem base move near the target object and align itself with the thing. within the second step, once the mobile golem base moves sufficiently near the target object, the aboard arm reaches and grasps the thing exploitation the image-based eye-to-hand visual servo management theme, as delineated [3 and 5]. Since the approach utilized in the second step is renowned, the current paper focuses totally on the event of the visual servo management law within the start.

A. CONTROL SCHEME:

The classical approach for fixed-base manipulators is extended for the motion management of WMRs, as schematically shown in Fig. 2. In Fig. 2, a CCD camera is mounted on the mobile base, that is ready to incessantly capture live pictures of the target object. The captured image is compared with the recorded desired image to work out the visual errors. exploitation the visual errors, the IBVS controller computes the specified speeds ω1 and ω2 of the wheels of the mobile golem, and sends them to the low-level proportional–integral spinoff (PID) controller of the golem. The golem then rotates and interprets incessantly till it reaches the specified position and orientation wherever the camera can observe the specified image.

Four sets of coordinate frames square measure outlined currently, namely, the golem frame, the camera frame, the image plane frame, and therefore the picture element coordinate frame, so as to derive the IBVS management law for the mobile golem. the connection between the primary 2 coordinate frames is shown in Fig. 1. In Fig. 1, the camera frame is stiffly hooked up to the camera whereas the golem frame is fastened to the mobile golem. The coordinate transformation between the 2 frames is given by

$$y_k = a_k w = \sum_{t=1}^{N_{nem}} a_{k,l}\, w_l \quad (4)$$

where w_l, l = 1, 2, 3, …, N_{nem}, is the content of the *l*th memory element, N_{nem} *w*] *T*, *ak*, *l* is the association index indicating whether the *l*th memory element is addressed by the state *sk* and *nem*. Since each state addresses exactly *Ne* memory elements, only those addressed $a_{k,l's}$ are 1, and the others are 0.

$$e^* + k_1 e = 0 \quad (1)$$

The above equation denotes that the rotor speed can able to track predefined trajectories asymptotically when $lim_{t\to\infty} e = 0$. Even though the parameters of the motor can be analysed, the external load and para-meter variations are commonly unknown. Thus it is hard to implement the ideal control law in practice. In order to overcome this drawback, and to control the robot effectively, a new control topology CMAC was proposed. THE control law of CMAC can be stated as follows,

$$u = u_{CMAC} + u_C \quad (2)$$

Where u_{CMAC} is the fuzzy CMAC control and u_C is the compensating control. The fuzzy CMAC control is used to approximate the ideal control law, and the compensating control is used to approximate the approximating error.

Assuming the existence of optimal CMAC output u_{CMAC}, the ideal control u can be expressed as follows,

$$u = u_{CMAC}(x_i, w^*, m^*, v^*, r^*) + \rho = \widehat{w}\widehat{\Gamma} + \rho \quad (3)$$

Where w^*, m^*, v^*, r^*, ρ denotes the infinitesimial error and optimal parameters. The control output can be written as,

$$u = u_{CMAC}(xi, \widehat{w}, \widehat{m}, \widehat{v}, \widehat{r}) + u_C = \widehat{w}\widehat{\Gamma} + u_C \quad (5)$$

Where $\widehat{w}, \widehat{m}, \widehat{v}, \widehat{r}, \widehat{\Gamma}$ denotes the estimated parameters.

Lyapunov function *Vc* is defined as follows,

$$V_c = \frac{1e^2}{2} + \frac{1\tilde{w}T\tilde{w}}{2\beta_\omega} + \frac{1\tilde{m}T\tilde{m}}{2\beta_m} + \frac{1\tilde{v}T\tilde{v}}{2\beta_v} + \frac{1\tilde{r}T\tilde{r}}{2\beta_r} \quad (13)$$

The following equations are derived by differentiating the above equation,

$$\dot{\widehat{w}} = \beta_w e \frac{1}{J_m} \widehat{\Gamma}$$

$$\dot{\widehat{m}} = \beta_m e \frac{1}{J_m} c\widehat{w}$$

$$\dot{\widehat{v}} = \beta_v e \frac{1}{J_m} G\widehat{w}$$

$$\dot{\widehat{r}} = \beta_r e \frac{1}{J_m} H\widehat{w} \quad (6)$$

The compensating controller discussed in the previous section was selected to compensate the error between the CMAC and the ideal control law. On the other hand, all of the neural network based learning algorithms require a course of learning for approximation of functions. In the initial learning stage, the approximation error of the fuzzy CMAC is little complicated, implying that a large compensation is needed. Accordingly, the compensating control discussed in [7] is quite easy, but in practical implementing a compensating controller for robot is difficult. Fig 2 shows the block diagram of the configuration of mobile robot. In practical real time applications, a large value of d may cause the control system to expose a better transient response than a small value of d, but it will also result in serious twaddle control phenomena in the steady state. If a small value of d is selected, then the unde-sired twaddle phenomena in the steady state may clearly be decreased, but the expected transient response cannot be retained. In addition, a very small d may destroy the conditions for stability. To overcome these problems, this paper develops an advanced improved compensating controller [8]. The main idea on which the advancement in the proposed controller depends is to increase the compensation of the fuzzy CMAC when it is in the initial learning stage which is also known as transient state and maintain also to maintain a suitable compensation when the fuzzy CM-AC has complete its learning (also known as steady state). Because an insufficient compensation may cause the control system to expose a large tracking error when the fuzzy CMAC is in the transient state, the trac-king error e can be used as an index, to identify whe-ther the fuzzy CMAC is in the initial learning stage.

IV. EXPERIMENTAL RESULTS:

The performance of various controllers was simulated using MATLAB and the results are analyzed. The robot is assumed to move along a path of 20*20 cm line with a constant velocity. The robot moves along the path based on the algorithm which is programmed using the microcontroller. In order to retrieve a realistic simulation based environment, we originate sensor measurements and ground based trajectory in a real time based simulation environment. To generate the ground based trajectory, the data-set was processed with the existing known algorithm, and the images are obtained at various time instants. In order to get the complete ground truth, we must generate the IMU states at the real-time environments.

To this extent we devise an optimization problem, to regulate the rotational velocity and acceleration signals which will (i) guarantee that the IMU pretense at the time instants is distinguishable to the estimates, and (ii) minimize the variation between the rotational velocity and ground-truth acceleration and the corresponding estimates obtained from the actual data-set. To this extent, we devise an optimization problem, to regulate the rotational velocity and acceleration signals which will (i) guarantee that the IMU pretense at the time instants is distinguishable to the estimates, and (ii) minimize the variation between the rotational velocity and ground-truth acceleration and the corresponding estimates obtained from the actual data-set.

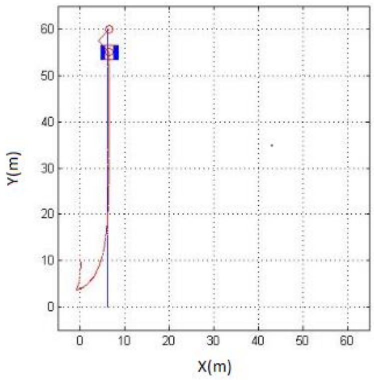

Fig 2: Results of the line trajectory tracking experiment by our estimator

This is due to the evidence that the time instant at which a feature is contemplated depends on the row on where it is projected and, for general motion, it cannot be computed provisionally. Therefore, in our erection we initially compute the projection of the feature.

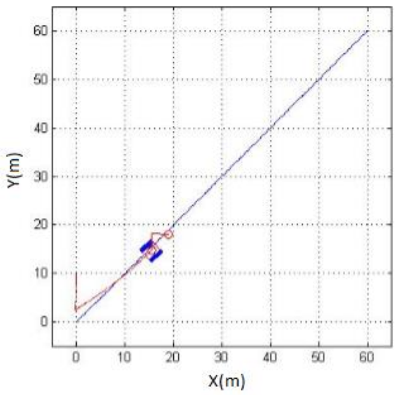

Fig.3 Results of the line trajectory tracking experiment by integration

IV.CONCLUSION:

This paper proposes a advanced and improved controller for visual servoing and trajectory tracking of non-holonomic mobile robots without the means of direct position measurement. In order to avoid the measurement of global position of the mobile robot that is usually paramount in the existing trajectory like tracking controllers, a novel adaptive fuzzy estimator has been devised to estimate the global position of the robots online, using natural visual features calculated by a vision system, and its orientation and velocity are measured by the odometry and attitude and heading reference system (AHRS) sensors. It has been proved by the Lyapunov stability theory that the proposed controller, along with the combination of embedded position estimator, gives inflammation to the asymptotic tracking of a derived trajectory and convergence of the position estimation of the robot to the actual position. To ensure that the real-time performance is perfect, GPU has been adopted to accelerate the computation by online processing of multiple SURF points in lateral. The result of the proposed controller has been verified by the experimental results and demonstrated its robust performance against the long-term accumu-lation errors of the noisy measurements. The effect of discontinuity, which is caused by features entering and leaving FOV of the camera, on the stability of our algorithm is an open theoretical topic to be addressed in the future.

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