OMNI DIRECTIONAL INDOOR MOBILE ROBOT

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ABSTRACT
This paper presents an approach, which uses an omni-directional robot for indoor use. The use of the omni-directional robot describes a 'no head no tail' robot. This will reduce movement recovery in time and space. In addition, its mechanism makes it possible to run as a reactive robot without any complex programming. This robot is designed to use an algorithm control (reactive) based on the vision control system. The aim of this project is to design an indoor mobile robot for jogging partner operation.

Keywords
Omni-directional, mobile robot, mechatronics, Jogging Partner.

1. INTRODUCTION

This paper is motivated by a unique robot made by the Manipulation Lab, Robotics Institute in Carnegie Mellon University. The robot is then licensed to a company called Acroname, Inc. for marketing purposes [1]. The robot is named Palm Pilot Robot Kit (PPRK).

The Omni-directional robot is required in order to make fast moves in rotations. In the previous work, the omni-directional special wheel is used by PPRK robot. The simple concept of it is shown in Figure 1.

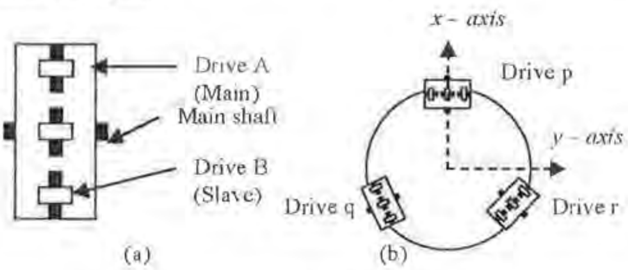

Figure 1. Wheel configuration

The wheels are produced by North American Roller Products (www.narp-trapo.com) through Acroname and Mr. Robot company. Perpendicular to the movement of the main wheel, there are small slave wheels. These small wheels allow the movement of the main wheel perpendicular (90 degree) to the left or right as in Figure 1(a).

The wheel is assembled to the body of the robot in the orientation of triangular pattern as in Figure 1(b). The control of the robot is quite complex, and it requires kinematics analysis to understand and control its direction.

If you want to go to any direction, you have to drive the wheel (Figure 2(b)) to that direction (Figure 2(c)); then you can drive the other two wheels synchronously. (two motors have to drive simultaneously) as in Figure 2(d).

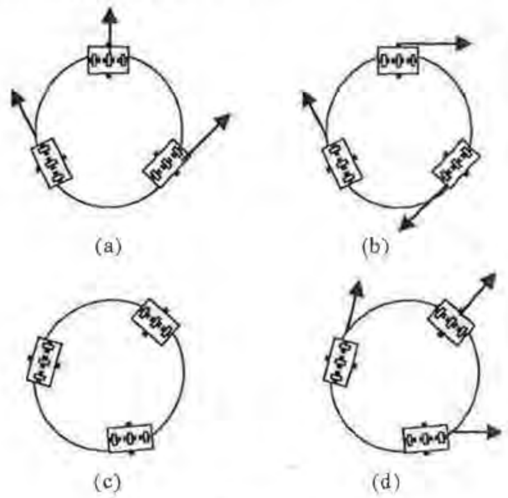

Figure 2. Direction control

2. SIMPLER MODEL

PPRK has several disadvantages, which are:

- Complex wheel design
- Complex algorithm for movement
- Gap in wheel structure (will result in image vibration)

The alternative design is made as simple as possible, but it has the characteristics of an omni-directional control drive. To meet all the necessary requirements, the undertaken strategies are:

1. Simple mechanism
2. Avoid the use of reverse or backward movement
3. No need to go forward for 'head of robot'
4. Simple operation of control strategy
5. Smooth operation for vision

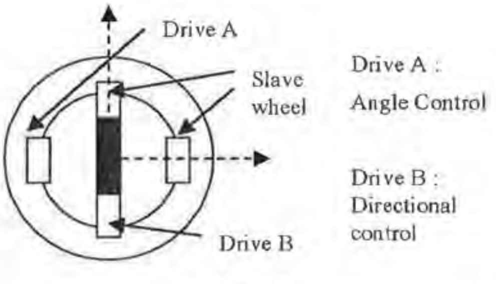

Figure 3

The result of this simpler concept is as in Figure 3. After about a few months, the final robot mechanism built is as in Figure 4.

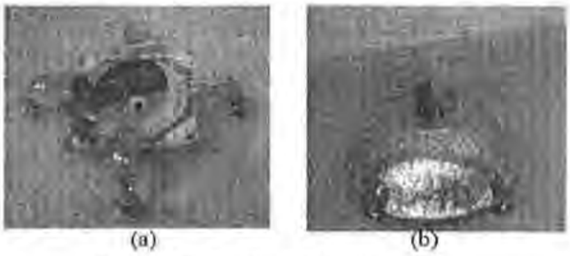
(a) (b)

Figure 4. (a)Inside. (b)Moving robot.

We have decided to focus on simpler mechanism first, in order to implement jogging partner robot. This is due to simplicity and straight forward mechanism relative to OMNI directional vision system. If this phase success, focus can be made on 3 wheels or 4 wheels OMNI directional control. Basic or correlation of OMNI directional vision system and OMNI directional motion have to be study at the first place.

3. ADVANTAGES OF OMNI & PROJECT DEVELOPMENT

The omni directionality of a motorized wheeled platform is a dream of many robotics engineers: indeed, to move freely on the floor, implies carrying out 3 distinct movements independently: longitudinal translation, side translation and self rotation corresponding to the orientation [4].

For an example, in the case of corner problems, there are two possible movements. Like in the test drive pad in Figure 5(a), in the situation of the upper-left corner, the path control can be as in (b) or (c). In (c), the path is considered successful, but there is a possibility that it gets stuck at the corner limit. Consequently, the control of the omni-directional robot can be easily moved to the right (b).

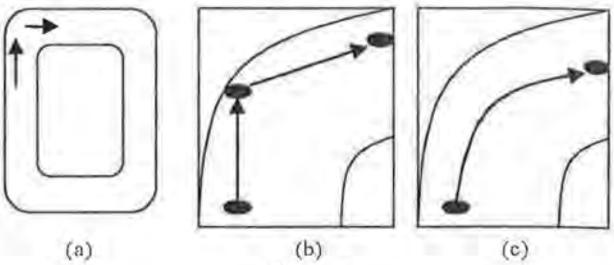

Figure 5

When comparing the conventional two drive motor mobile robot operations, it can be said that whenever it gets stuck in a corner, it has to make a reverse operation (border constraint – Figure 6(b)). Omni-directional robot will eliminate/reduce reverse techniques as much as possible.

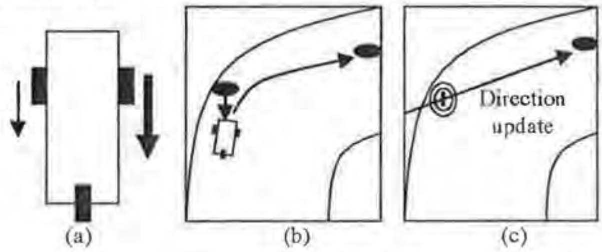

Figure 6

The first problem encountered in building such a robot is that the 'slave' wheel tends to drive the robot in a 'slave' direction. According to the plan, the slave must be passive in giving response to the control wheel. Then, by changing to the omni-directional slave wheel and adding more slave wheels, the effect is minimum.

The stage of this research is still in its early development, but it introduces the concept of 'No head No tail' Mobile Robot. Any directions can be considered the head; this strategy makes it responds quickly to the task given as following the path guide as in Figure 6(c).

The use of PPRK forces to rotate the body of the robot; this is different in design as in Figure 6(c). The robot does not have to rotate; only the wheel is planned to find out its new way of direction.

Our mobile robot has to select omni-directional mechanism due to our guidance control scheme designed. For now, the camera is attached to the direction of the wheel; therefore, every time the robot changes its direction, the camera is also moved to the new direction (Figure 7).

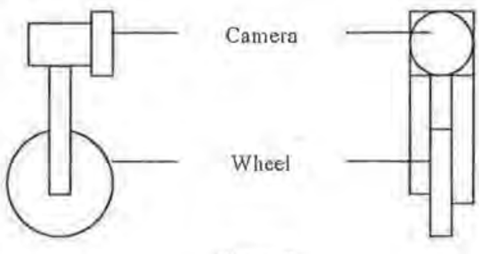

Figure 7

For the control system as in Figure 8, the image is already in a normal format. Hence, it is easier to process the images and movements.

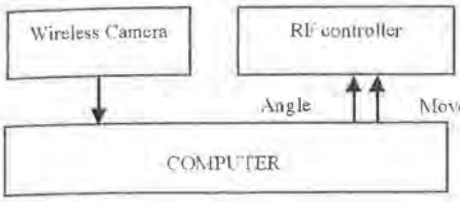

Figure 8

Matrox software planned to be used to process the images. VB for algorithm control. The other step, the Omni-Directional Vision (ODV) system, is proposed to be implemented in the Omni-directional robot. In this case, the camera is pointed up as in Figure 9(a). A special reflected mirror is used above the camera as in Figure 9(b).

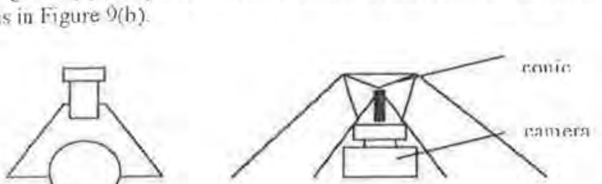

Figure 9. (a) Pointing up Camera. (b) Conic reflected mirror.

Our early research on this technique can be seen in Figure 10. It is not a curved image, but a surrounded image. The Conformal Mapping can be used in re-mapping the image taken by the camera [2]. The expansion of view angle of the camera will result more stable vision matching in the view-based navigation [3].

Figure 10. (a) ODV system. (b) Image taken.

If the conic is perfect, then conformal mapping:

$$w = |z| + i\theta_z \quad \text{(Equation 1)}$$

$$\text{where } |z| = (x^2 + y^2)^{1/2} \text{ and} \quad \text{(Equation 2)}$$

$$\theta_z = \tan^{-1}(y/x) \quad \text{(Equation 3)}$$

The challenge part is to process the real images, this is due to non-linearity in images. The objective of this project is to produce the final operation as in Figure 11. The object represents people who might present in the robot's vision scope.

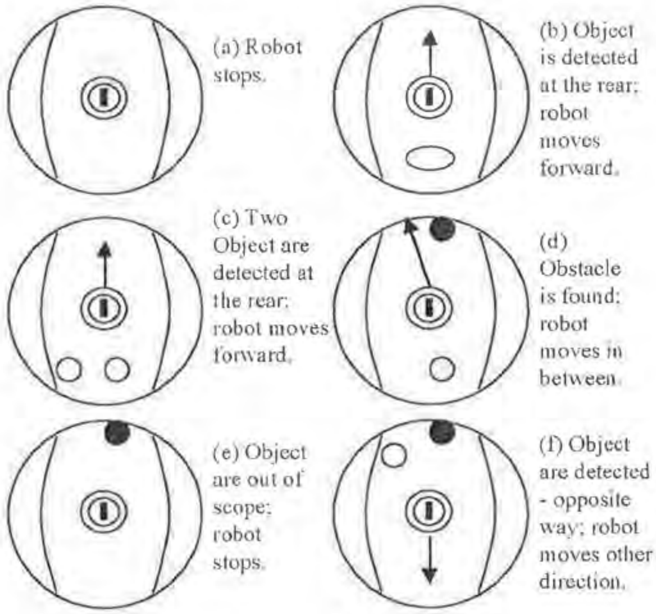

Figure 11

4. CONCLUSION

In this simple paper, we merely provide the development of the ODV robotics project. It describe the early state of Jogging Partner Robot design (service robot) and the direction of the project. Thus can boost up motivation among our team. For further details regarding the project and multi agent ODV robotics project, reader(s) can contact the researchers. For those who are interested, the position of Research Assistant (RA) or Research Officer (RO) in KUTKM can be arranged and offered in relation to this paper. We are waiting for any candidates to join us.

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