Chapter 29
Motion Control of an Omni-Directional Walker for Walking Support

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ABSTRACT

With the increase in the percentage of the population defined as elderly, increasing numbers of people suffer from walking disabilities due to illness or accidents. An omni-directional walker (ODW) has been developed that can support people with walking disabilities and allow them to perform indoor walking. The ODW can identify the user's directional intention based on the user's forearm pressures and then supports movement in the intended direction. In this chapter, a reference trajectory is generated based on the intended direction in order to support directed movement. The ODW needs to follow the generated path. However, path tracking errors occur because the center of gravity (COG) of the system shifts and the load changes due to user`s pressure. An adaptive control method is proposed to deal with this issue. The results of simulations indicate that the ODW can accurately follow the user's intended direction by inhibiting the influence of COG shifts and the resulting load change. The proposed scheme is feasible for supporting indoor movement.

INTRODUCTION/BACKGROUND

In a super-aged society with a low birthrate, such as Japan, an increasing number of people suffer from *walking impairments* caused by illnesses or accidents. In order to perform indoor movement freely in daily life, elderly people need devices to provide support. At present, several devices, including canes, folding walkers, and caster walkers, are used. Those devices are also being used to do walking exercises to enhance leg muscle strength. However, the danger of falls, especially when the users have severe walking disabilities, is not sufficiently considered. Thus the safety of

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those devices is low. Therefore, it is important to develop a walking training machine that can ensure the safety of the user while supporting walking and assisting walking exercises.

In previous studies, the authors of the present paper, along with other colleagues, developed an *omni-directional walker (ODW)* for both *walking rehabilitation* and *walking support* (Wang, Kawata, Ishida, Yamamoto, & Kimura, 2001). In walking rehabilitation, the user follows the walker`s movement. Training programs are stored in the ODW such that rehabilitation can be carried out without the presence of physical therapists. The effectiveness of the ODW in walking rehabilitation was verified by clinical tests (Wang et al., 2007; Ishida, Wang, Nagano, & Kishi, 2008). In order to follow precisely the training programs defined by physical therapists, an adaptive control algorithm was developed to address the center of gravity (COG) shift and the load changes caused by the users (Tan, Wang, Jiang, Ishida, Fujie, & Nagano, 2011; Tan, Wang, Jiang, Ishida & Fujie, 2011). Simulation and experimental results demonstrated the feasibility and effectiveness of the proposed adaptive control method. In walking support, the user wants to go somewhere, and the walker needs to follow the user to provide support. It is necessary for the ODW to know the direction the user intends to go based on user manipulation. A novel interface is proposed for the ODW to recognize directional intention according to the user's forearm pressures, which are measured by force sensors embedded in the armrest (Jiang, Wang, Ishida, Ando & Fujie, 2010a, 2010b). The relationship between forearm pressures and directional intention was extracted as fuzzy rules, and an algorithm was proposed for directional intention identification based on the distance type fuzzy reasoning method (DTFRM) (Wang, Tsuchiya & Mizumoto, 1999, 2000). The effectiveness of the algorithm was verified by experimental results. However, in the previous experiments concerning walking support, the ODW moves only when the force sensors detect forearm pressure. Forearm pressures have to be continuously exerted in order to keep the ODW moving. However, the detected direction is not stable, due to the time-varying pressures based on the user`s motor function, which leads to low accuracy and safety. The intended direction does not usually change during a one-time movement. We also developed a new method using one time intended direction detection to support the user reaching the destination.

In this chapter, a reference trajectory is generated based on a single detection of direction intention, and an adaptive control method is proposed to control the ODW to move in the intended direction. With this method, the ODW can keep moving in the intended direction until a distinctly different directional intention is detected. A simulation is executed, and the simulation results are shown.

OMNI-DIRECTIONAL WALKER

Structure of Omni-Directional Walker

The structure of the ODW is shown in Figure 1. The most important feature of the ODW is the use of omni-directional wheels. An arrangement of four omni-wheels at the bottom of the walker body enables the walker to move in any direction while maintaining its orientation.

Figure 1. Omni-directional walkers and one of its omni-directional wheels

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