THE DEVELOPMENT OF A ROBOTIC TRAINER FOR THE CORRECTION OF ABNORMAL HUMAN GAIT

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In this study, we developed a robotic gait trainer which induces the gait training based on predefined continuous proper lower extremity joint movements for the paralysis. AC servo motors and linear actuators were used to control hip and knee joints of patients and the weight support system was used to support the patient's weight during the gait training. We also implemented a GUI program to set the gait training pattern with several training parameters and to confirm states of patients and the system through the visual feedback. The effectiveness of the gait trainer will be determined by the long-term clinical experiments in the future. We expect that the developed robotic gait trainer could be applied very practically to recover gait abilities for persons with gait disorder.

KEY WORDS: robotic gait trainer, gait disorder, visual feedback.

INTRODUCTION:

The gait, one of specific body functions of the human, is the most common exercise and a basic daily activity. The gait training has a very important role to improve the level of independence and the quality of good life for the patients who lose the walking ability(Patla, 1995).
The gait training used to be applied by using remain senses in order to acquire the ability which is necessary to walk independently for the people who has problems in movement. Comprehensive care of the specialists in different fields were requested for the rehabilitation training to recover walking abilities of patients with gait disorders. In addition, repeated and systematic gait trainings were also required to improve the sense of balance and the perseverance of the patients(Wade, D.T. et al., 1987).
Traditionally, subjective diagnoses and manual treatments were used for the rehabilitation of patients with gait disorders after the stroke. On the middle of 80’s, Barbeau et al.(1989) proposed the gait training on the treadmill with the body weight support. Wernig and Auuler(1992) also reported clinical effects through the gait training of stroke patients on the treadmill with partial body weight support. However, conventional training methods, e.g. treadmill gait training, required great physical efforts from physiotherapists to assist the patient, so does even more training of gait guided by at least two or three physiotherapists. The patient’s legs are guided by therapists holding and moving them along a gait-like trajectory. The tremendous physical effort of the therapists often limits the training duration, whereas the patient might benefit from a longer duration(Hesse, S. et al., 1995). In domestic studies, the intelligence walking training robot was developed for the gait training of patients(Sung, Y.G., 2001). However, it couldn’t provide normal gait patterns for training and also couldn’t induce active gait trainings, because its movement was limited by only the direction which patient oneself intended like a walker.
In this study, we developed a robotic gait trainer which induces the gait training for the paralysis with gait disorders based on predefined continuous proper lower extremity joint movements using AC servo motors and linear actuators.

METHOD:

System Design: In Figure 1, we designed the driving part of the robotic gait trainer using a commercial software(AutoCAD 2006, Autodesk Inc., U.S.A). The small-sized and lightweight AC servo motor(HC-MFS23: Max. torque 1.9N.m/kg, Max. rotation speed 4500rpm, MITSUBISHI ELECTRIC, Japan) which could induce enough maximum joint moment(hip joint moment: 1Nm/kg, knee joint moment : 0.5Nm/kg)(Winter, D.A., 1990) and joint rotation velocity which was required during walking was selected. In addition, we designed the linear actuator which was composed ball screws and ball nuts which convert rotations of motors into translational motors, so possible to vary the length of the driving part as specific length. The upper leg and lower leg part of driving part were designed to adjust the length as suitable of the patient. The encoder(E40H8-3600-6L-5, Autonics, Korea) was placed at each joint to measure angles of joints. Additionally, the loadcell(U2D, KOREA LOADCELL & SYSTEM, Korea) was used to measure forces from the driving part to joint during the gait training.

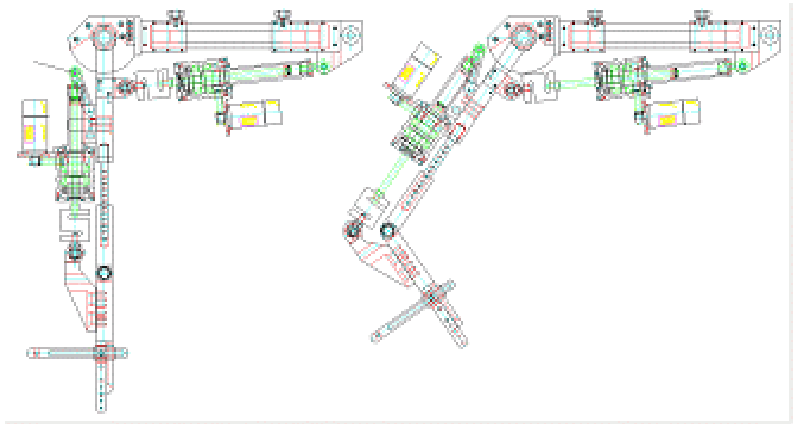

Figure 1: The driving part of the robotic gait trainer

The whole size of the robotic gait trainer was designed as 2.30m(W)*1.35m(L)*2.80m(H) through considering the size of base treadmill, the height of patient and stride length/step length so on. In addition, we established the harness which could support until maximum 200kg to support patient's body weight during the gait training(Figure 2). Safety side bar, system door and lifting device were also established for convenience.

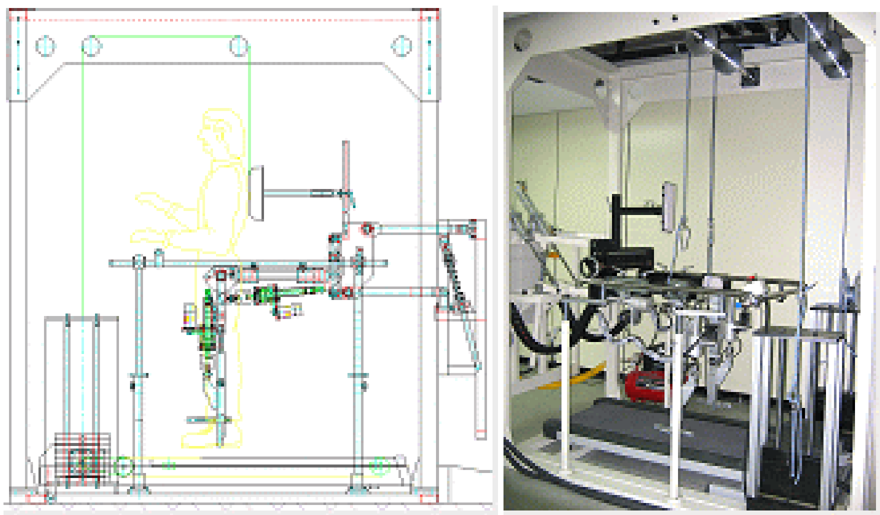

Figure 2: The weight support system of the robotic gait trainer

Gait training program GUI: We developed GUI(graphic user interface) to control the gait training program of the robotic gait trainer using commercial software(C++bulider2006, Borland, U.S.A.). As shown in Figure 3, gait patterns of both lower limbs during one gait cycle could be provided as an input by loading the patient's gait pattern file. Training parameters such as gait velocity, the number of gait cycle, the maximum permission angle of each joint and others also could be set in GUI. In addition, the initial joint angle and position were set by miniature proximity sensors of the driving part, and joint angles were measured by encoders of each joint. The database of the gait training was also established by saving information of patients and training log.

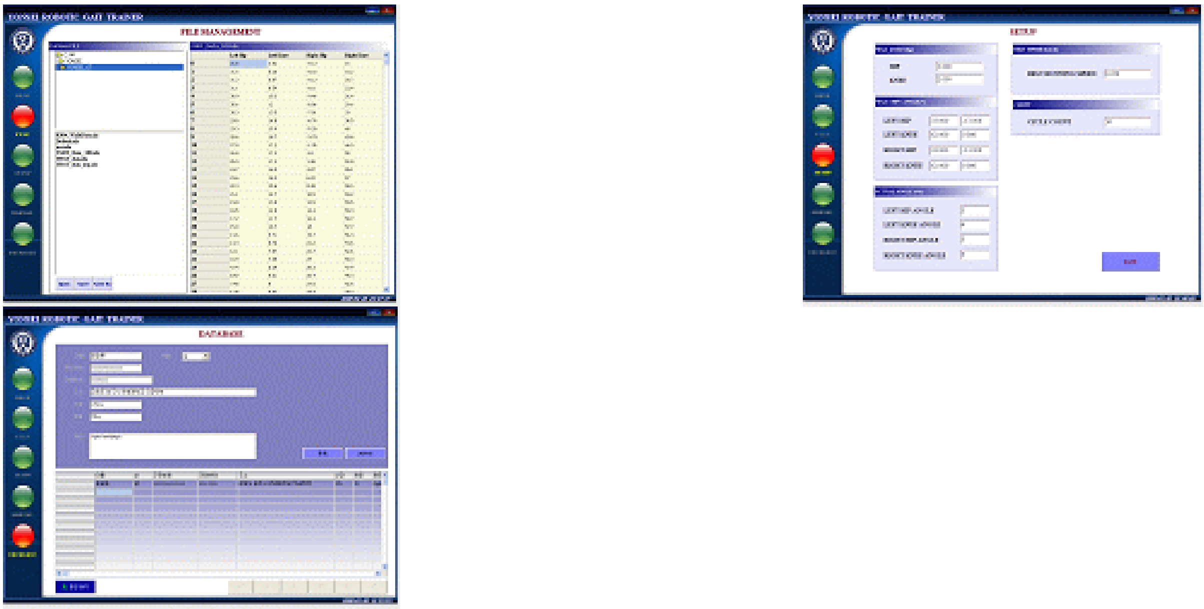

Figure 3: Setting of gait training parameters and database

As shown in Figure 4, the simulation mode was set to judge the patient's and the appropriateness for the running condition of the system. Additionally, the visual feedback also developed to confirm the condition of both patients and system during the gait training. The emergency stop was designed to stop the system immediately when an unexpected situation occurred.

Figure 4: Main GUI of gait training program

System Hardware Setting: The hardware device was set in an industrial PC(Intel(R) Pentium(R) Dual CPU E2160@1.80GHz 1GB RAM, O/S: Windows XP) to control the robotic gait trainer. Motion control module(SMC-4V04, AJINEXTEK, Korea) which had motion control IC(CAMC-QI, AJINEXTEK, Korea) and A/D Board(NI6220, NI Cop., U.S.A.) were established in the PC.

RESULTS:

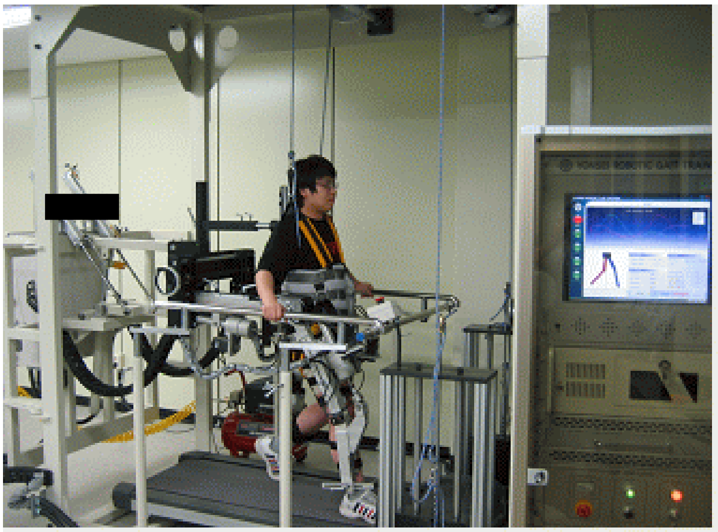

Figure 5: Developed robotic gait trainer

CONCLUSION:

Conventional gait training methods, e.g. treadmill gait training, required tremendous physical effort from physiotherapists to assist the patient. A robotic gait trainer which induces the gait training based on predefined continuous proper lower extremity joint movements was developed in this study. AC servo motors and linear actuators were used to control hip and knee joints of patients and the weight support system was used to support the patient's weight during the gait training. The GUI program was designed to set the gait training pattern with several training parameters and to confirm states of patients and the system through the visual feedback. In future study, the effectiveness of the gait trainer will be determined by the long-term clinical experiments. We expect that the developed robotic gait trainer could be applied very practically to recover gait abilities for persons with gait disorder.

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