Original Articles/นิพนธ์ต้นฉบับ

Clinicon: A Service Robot Designed to Position and Transport Patient: First Conceptual Design and Applications Report

Chumnanvej S, M.D.[1,2], Sattayasoonthorn P[2,3], Puanhvuan D[3], Rohitasathira N[3], Suthakorn J, Ph.D.[2,3,4]

[1] *Neurosurgery Division, Department of Surgery, Faculty of Medicine, Ramathibodi Hospital, Mahidol University*

[2] *Center for Biomedical and Robotics Technology (BART LAB), Department of Biomedical Engineering,*

[3] *Department of Biomedical Engineering,*

[4] *Department Chair and Assistant Professor, Department of Biomedical Engineering / Adjunct Faculty, Department of Mechanical Engineering, Faculty of Engineering, Mahidol University*

Abstract

Generally, patients are needed to lift and move by doctors, nurses or medical assistances in the hospital. Simple pick and place patient is the usual way performing in hospitals and other medical services, particularly during emergent situations, within the operating room or changing to another hospital room or transporting to the other hospital. Transporting procedure are mainly essential for paralyzed or obese patients. In this present study, the robot called Clinicon, was presented with the feasibility and conceptual design to assist the medical teams to transport and also to position the patients particularly in the operating room with safety concern. The first main conceptual system of Clinicon consists of the line-follow tracking system and the designed manipulator for transporting and positioning the patient to perform the task only in the operating room. However, this is still the conceptual design, the practical version robot; Clinicon, is quite challenge to be built in the future.

Keywords: Clinicon, service robot, position and transportation, patients

Corresponding Author: Chumnanvej S, M.D.

Neurosurgery Division, Department of Surgery, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand. Email: rasorayouth@mahidol.ac.th

1. Introduction

Whilst the modern technology advanced to the point where the robots are feasible and able to do the jobs of humans generally did, particularly in the industry, the autonomic robot can alleviate the burden in several kinds of industrial procedures. Basically, the transportation is the common procedure which the robot is competent and also the accuracy, precision with high safety is well accepted in. Consequently, the robotic application in medical transportation is potential to be used. Clinically, patient transportation is a common and important routine job in the medical care[1,2]. Several patients are lifted and moved by doctors, nurses and medical assistances in the hospital. Simple pick and place patient is necessary in hospitals and other medical services, particularly during emergent situations. So, patients transporting device is a hospital prerequisite to facilitate the patient especially within the large operating room, changing to another hospital room or transporting to the other hospital. Transporting procedure and device must be 24 hour-available mainly for paralyzed or obese patients. A large variety of patient conditions as well as circumstances influence how to transport the patient. Concerning the patient safety, to facilitate safely move injured, recovering or postoperative patients on stable equipment, a transporting boards carrying on the stretcher are commonly used[2]. Some patient transporting equipment that is specialized for obese or pediatric use is also available designed for medical uses. Most transporting devices have a specific mode of transport either in a seated, supine, prone or lateral decubitus position. Patient safety is paramount for patient transportation and it should be easy or friendly to use for the medical care team. Generally, many doctors, nurses or medical assistances experienced backache or injured because they endeavor to lift or move a patient improperly along bed to bed or from stretcher to the table before and after surgery[3-6]. As a result, this common problem is the major concern of this study. Automatically robot designed for the patient transporting devices is the solution in order that the medical care team will not get injured while they are moving patients. Safety service robot for patient transportation was determined on a conceptual design and created in the Center for Biomedical and Robo-tics Technology (BART LAB) at the Department of Biomedical Engineering, Faculty of Engineering, Mahidol University. The objective of this study is to engineer the positioning and transporting patient robot which is called Clinicon. This paper describes the Clinicon system overviews including mechanical design, motor control design, its anatomy, task experiment with prototype construction, and pre-clinical experiment.

2. System Overview of Clinicon

Clinicon system overview is described. It was designed to perform its task in 2 modes; “automatic mode” and “manual operating mode”. Figure 1 illustrated the block diagram of the overview system including automatic mode and manual operating mode. In automatic mode, Clinicon was able to move automatically between stations using the line detection approach. A pattern of black line which was assigned on the path floor was detected by infrared (IR) sensing system on the robot then generated signal which was transported to the microcontroller unit (MCU) to drive the motor. Finally, Clinicon moved along the black line automatically. In manual mode, user was able to control the robot; Clinicon, by manipulating the joystick. With the same procedure of controlling motor as automatic mode, the difference is based on using limited switch to feedback the limited position of manipulator signal to MCU. The overall organization of Clinicon comprised of mechanical part and electrical part.

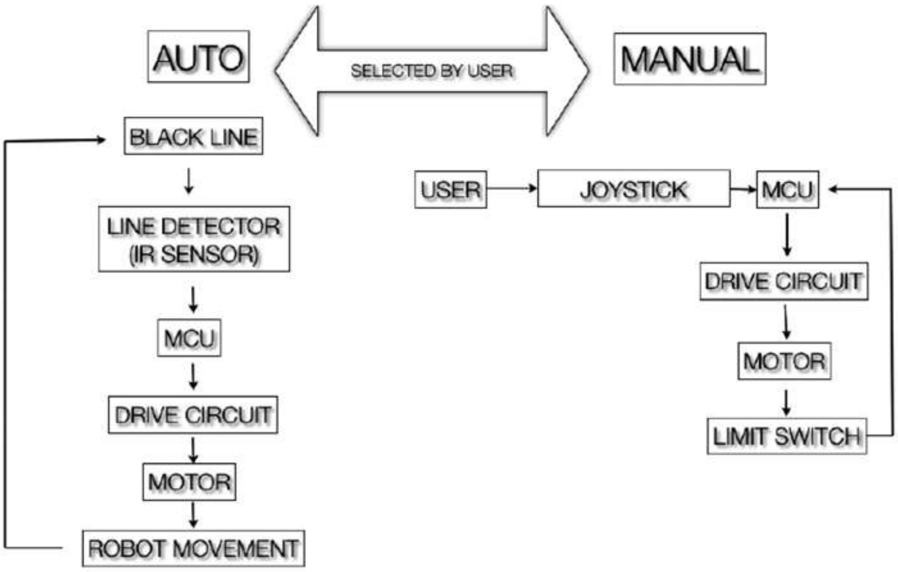


Figure 1 *Block diagram of CLINICON*

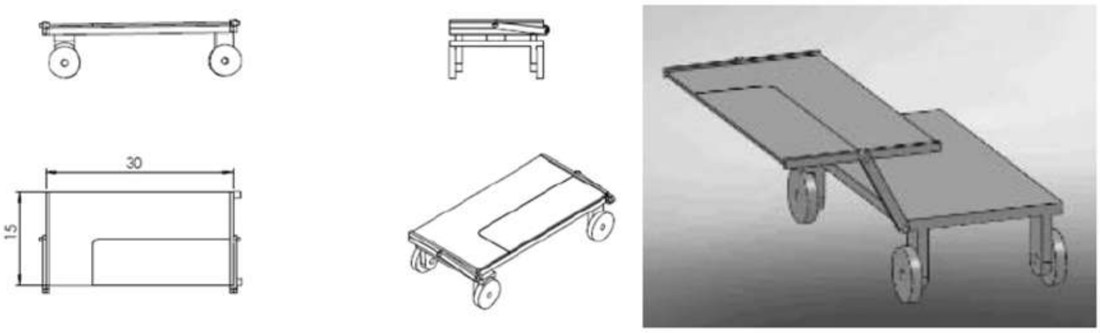
2.1 Mechanical Design

Clinicon is a prototype of service robot as shown in Figure 2 which was designed to do corporative work with doctors, nurses, or medical assistances in the hospital. There are four wheels. Two front wheels are the main controlled wheels which used to move, turn left or right. The other two back wheels are freely movement. Clinicon comprises of two main parts, the first part is a base which is designed to perform in translation 2D planar on the ground. The second part is the manipulator with special design for translating and rotating patient in prone, supine, left and right lateral decubitus position. It combines with two joints.

2.2 Motor Control Design

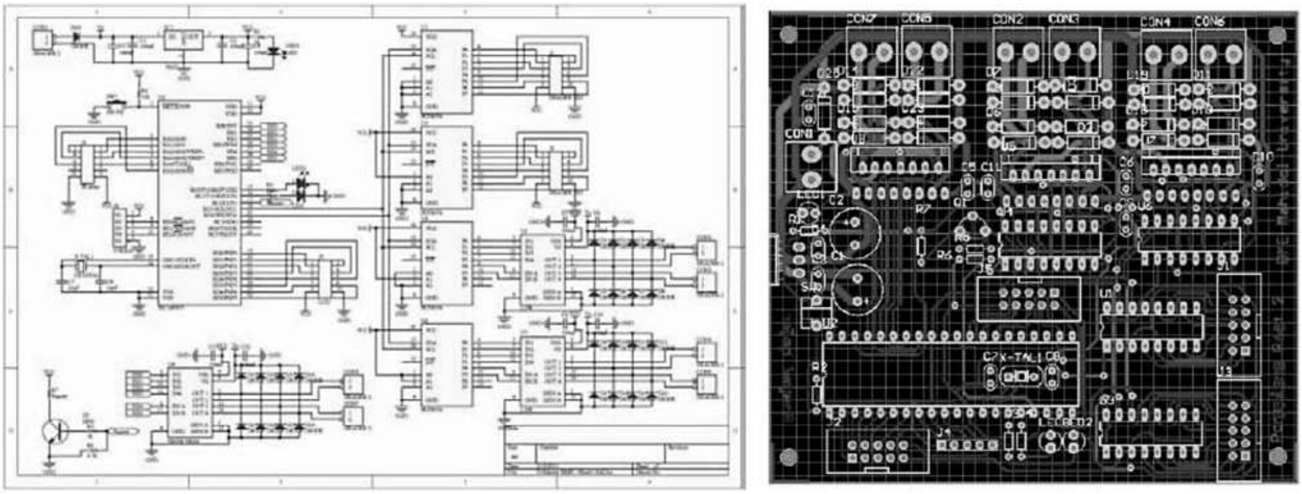
2.2.1 Electrical part

The main board in Figure 3 has a microcontroller (PIC16f877) which is used to control Clinicon. It receives the logic input from IR sensors, limited switches and joystick to control each motor by using integrated circuit (IC L298N).



(a) (b)

Figure 2 *(a) Top, front, right and isometric view of CLINICON. (b) 3D model of CLINICON*



(a) (b)

Figure 3 *(a) Control board schematic (b) Control board PCB (printed circuit board)*

2.2.2 Basic line detection

The IR sensor consists of infrared transmitter (Tx) and infrared receiver (Rx) as shown in Figure 4. When IR sensor detects the white object, the infrared light will reflect to Rx. In contrast, the reflection will not be occurring when IR sensor detects the black object because back object will absorb infrared light. The changing voltage from Rx depends on white and back object, which can be detected by "Schmitt - trigger" or "comparator" to give output logic for indicating white and black object.

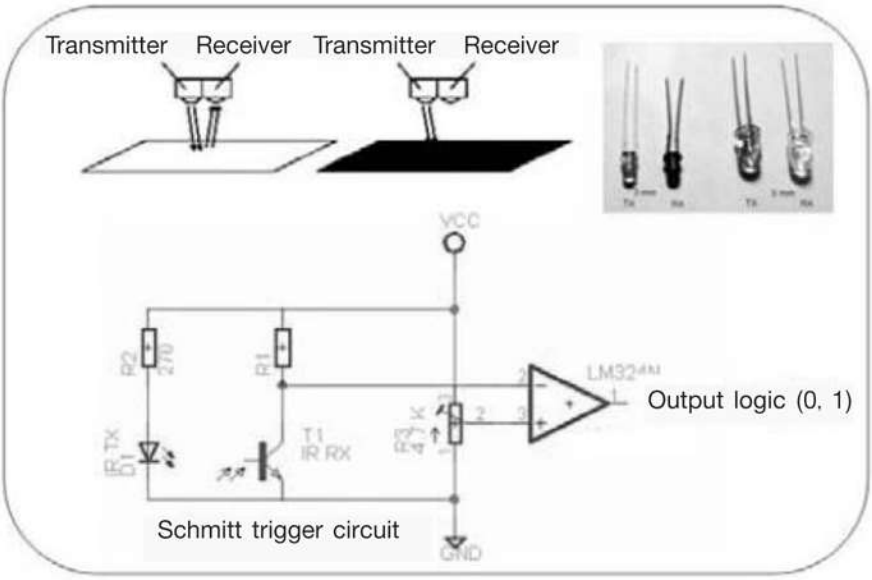


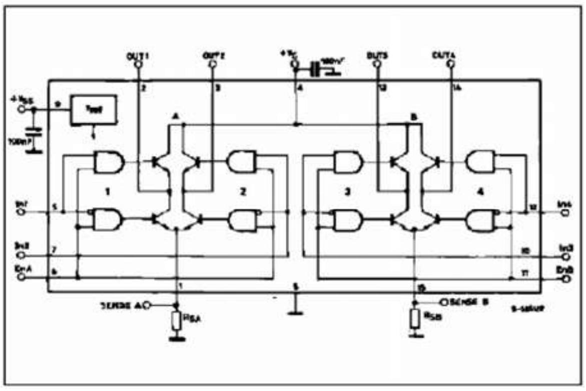
Figure 4 *The principle of line detection*

2.2.3 Basic Motor drive

From Figure 5, the IC L298 Motor Driver has 4 inputs to control the motion of the motors and two enable inputs which are used for switching the motors on and off. To control the speed of the motors, PWM waveform with variable duty cycle is applied to the enable pins. Rapidly switching the voltage between Vs and GND, this gives an effective voltage between Vs and GND whose value depends on the duty cycle of PWM

3. The Anatomy of CLINICON

Clinicon was completely assembly as shown in Figure 6 and 9 respectively. From Figure 7 and 8, its' joystick was designed and ease to control in sharing control mode. It was attached at the back of Clinicon and available to use when needed. The line detector was built in at the front of Clinicon as in Figure 9 a, to allow Clinicon moving automatically along the black line.



(a)

Inputs		Function
V_{en} = H	C = H ; D = L	Forward
	C = L ; D = H	Reverse
	C = D	Fast Motor Stop
V_{en} = L	C = X ; D = X	Free Running Motor Stop

L = Low H = High X = Don't care

(b)

Figure 5 *(a) Internal schematic IC L298, (b) Truth table of IC L298*

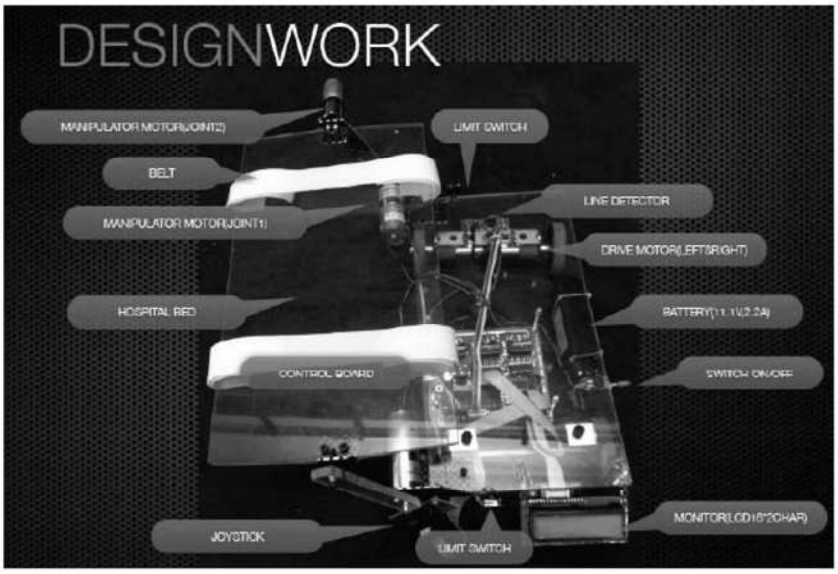


Figure 6 *overview of CLINICON*

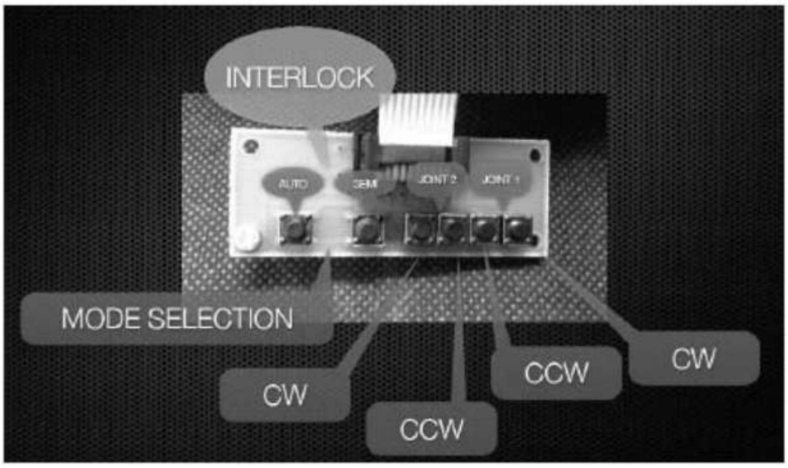


Figure 7 *Joystick (CW: clock wise direction, CCW: counter clock wise direction)*

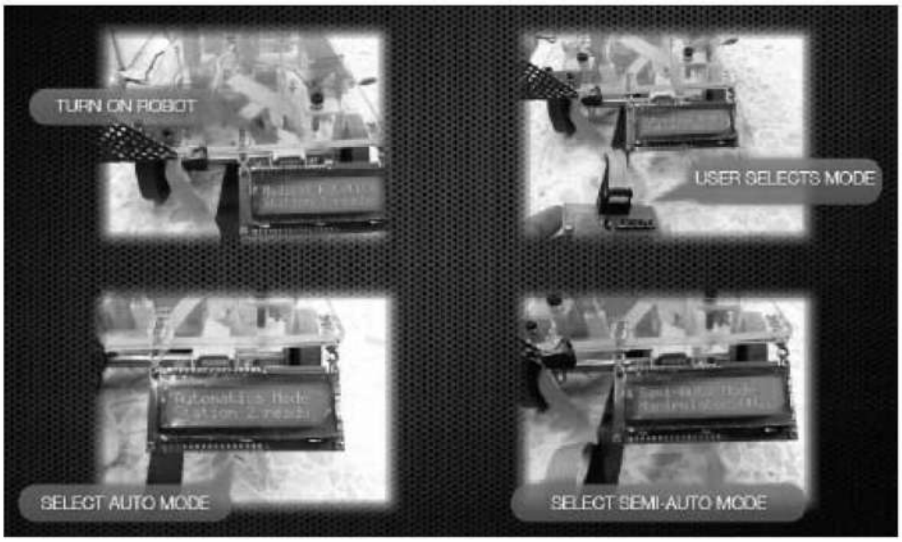
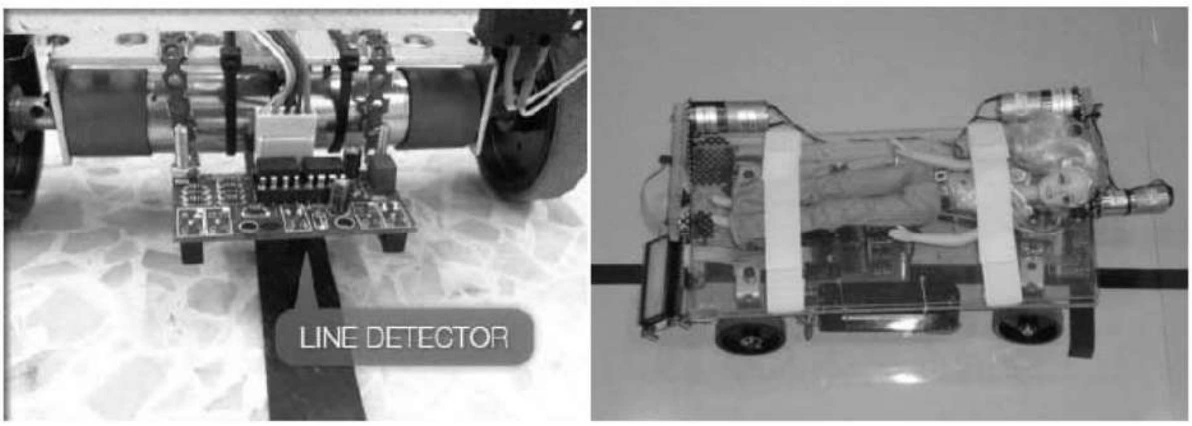


Figure 8 *16x2 character LCD monitor*



(a) (b)

Figure 9 *(a) Line detector circuit board, (b) CLINICON is moving automatically follows the black line*

4. The Experiment

4.1 Clinicon's path model

The path model was designed as Figure 10 and supposing to be the operating room condition. The task experiment conditions comprised of three stations with three stopping points for the robot to do its tasks. According to the tasks, Clinicon was programmed to start at the first station after the patient was loaded. Then, Clinicon ran along the black line automatically to the second station and stopped at the stopping point. At the second station, the patient was transported and positioned to the operating table in shared control mode by joystick controlling. Finally, Clinicon subsequently transported the patient from the second station to the third station to end its programmed task. Throughout this task experiment, Clinicon ran automatically with smooth and fluently along the black line sensor detection. While doing the shared control mode with joystick, the manipulator was prompted to transport and position the patient as the desired expectation.

4.2 At the stations

There are four positions which Clinicon capable to position the patient in sharing control mode at the second station including supine, prone, right lateral decubitus or left lateral decubitus. As Figure 11, the patient position was set by joystick control which was already programmed by pushing the designed button.

5. Conclusion

Clinicon is engineered as a conceptual prototype based on the medical robotics technology at the Department of Biomedical Engineering, Faculty of Engineering, Mahidol University. Concerning the conceptual design, Clinicon is feasible to facilitate the patient transportation and anticipated to service doctors, nurses and medical assistances both automatically mobile and by control operation to perform a variety of patient position including supine, prone and lateral decubitus in the best safety profile. The anticipation to develop the further version of this conceptual service robot; Clinicon, is potentially feasible. The human physiological parameters including vital signs, oxygen saturation or end tidal CO_2 and also other medical devices such as ventilators or warmer are possible to assembly. Compiling with the best communication system, this robot could provide the

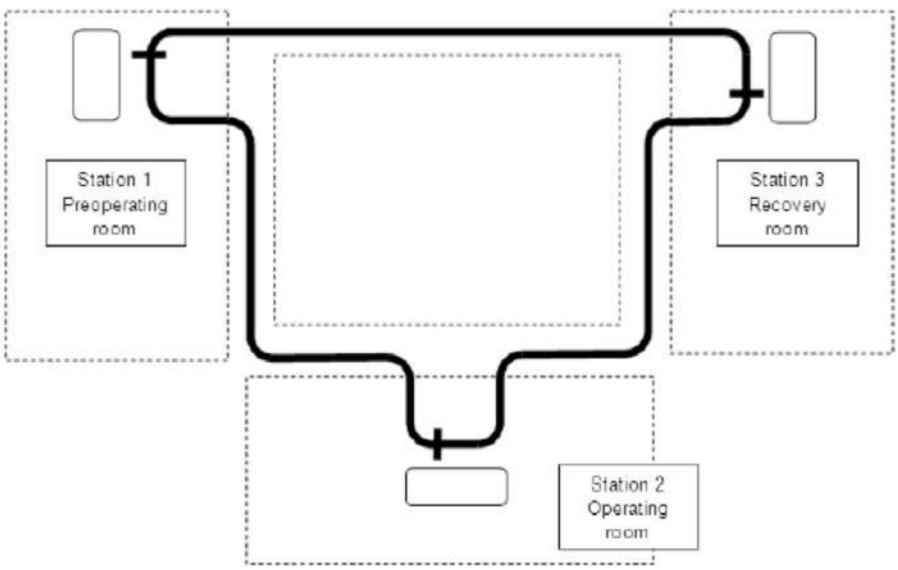


Figure 10 3 stations of path model experiment interaction communication. It is possible to upgrade this robot capacity to facilitate the medical team in a variety of monitoring and moving the patient for more distance and safe in several conditions including war field or disaster area.

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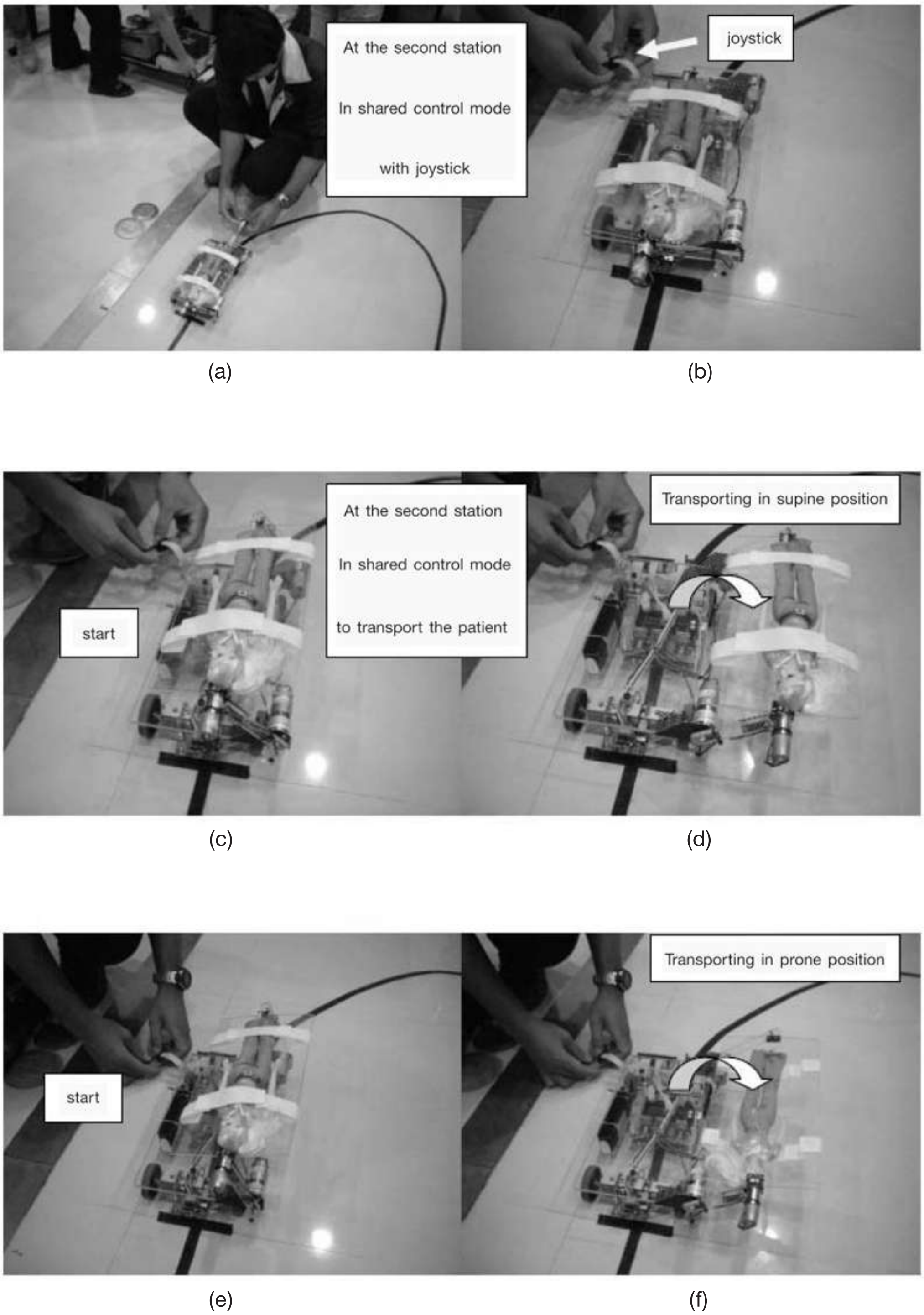
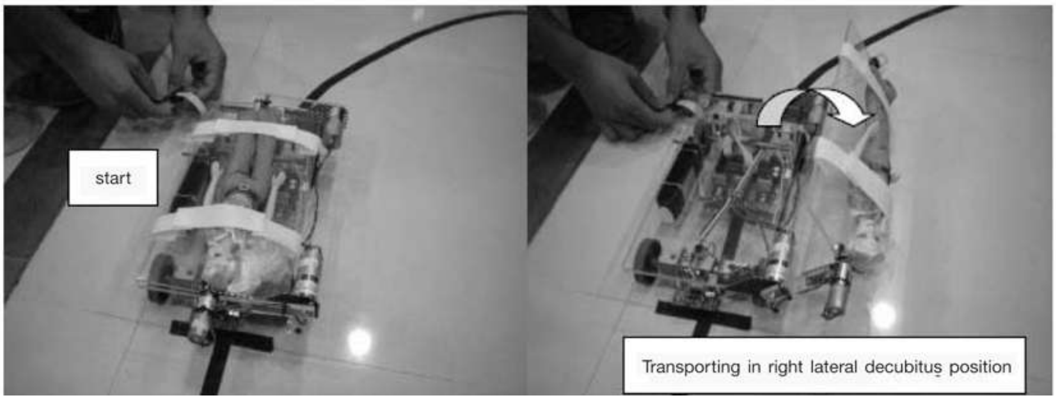
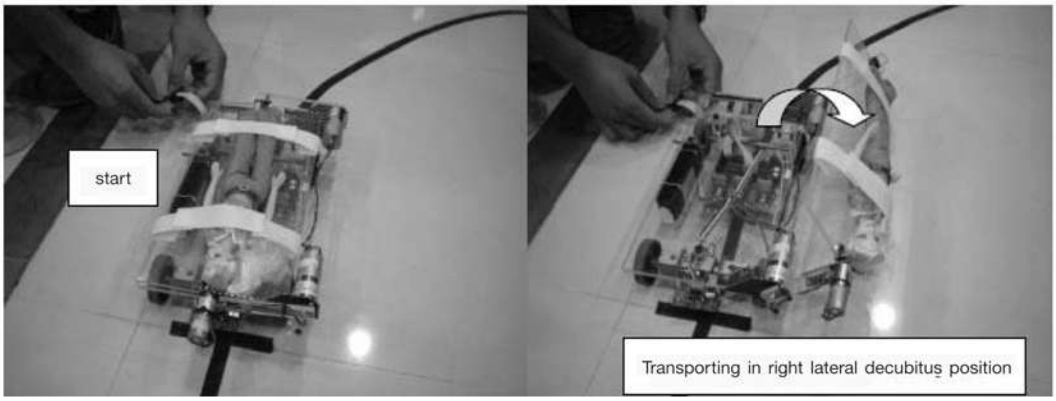




(g) (h)



(i) (j)

Figure 11 *4 positions alignment; supine, prone right and left lateral decubitus, by CLINICON*

References

1. Overd A. Should we lift or should we roll? Nursing practice following prosthetic hip surgery. Prof Nurse. 1992;7:311-9.
2. Santaguida PL, Pierrynowski M, Goldsmith C. Comparison of cumulative low back loads of caregivers when transferring patients using overhead and floor mechanical lifting devices. Clin Biomech (Bristol, Avon) 2005;20:906-16.
3. Lariviere C, Gagnon D, Loisel P. The effect of load on the coordination of the trunk for subjects with and without chronic low back pain during flexion-extension and lateral bending tasks. Clin Biomech (Bristol, Avon) 2000;15:407-16.
4. Lynch RM, Freund A. Short-term efficacy of back injury intervention project for patient care providers at one hospital. AIHAJ 2000;61:290-4.
5. Kindblom-Rising K, Wahlstrom R, Ekman SL. Nursing staff's perception of changes in patient transfer habits after a course - a phenomenological-hermeneutic study. Ergonomics 2007;50:1017-25.
6. Waters TR. Introduction to ergonomics for healthcare workers. Rehabil Nurs 2010;35:185-91.

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Original Articles/นิพนธ์ต้นฉบับ

"คลินิกคอน" หุ่นยนต์บริการที่ถูกออกแบบมาเพื่อการขนย้ายและช่วยจัดท่าผู้ป่วย รายงานหุ่นยนต์ต้นแบบและแนวความคิด

สรยุทธ ชำนาญเวช[1,2], ปรีดิพัทธ์ สัตยสุนทร[2,3], ดิลก ปึนฮวน[3], ณัฐวุฒิ โรหิตเสถียร[3], จักรกฤษณ์ ศุทธากรณ์[2,3,4]

[1] *หน่วยประสาทศัลยศาสตร์ ภาควิชาศัลยศาสตร์ คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี มหาวิทยาลัยมหิดล*

[2] *ศูนย์เครือข่ายวิจัยประยุกต์ทางเทคโนโลยีหุ่นยนต์และชีวการแพทย์ (BARTLAB) ภาควิชาวิศวกรรมชีวการแพทย์ คณะวิศวกรรมศาสตร์ มหาวิทยาลัยมหิดล*

[3] *ภาควิชาวิศวกรรมชีวการแพทย์ คณะวิศวกรรมศาสตร์ มหาวิทยาลัยมหิดล*

[4] *หัวหน้าภาควิชาวิศวกรรมชีวการแพทย์/ วิทยากรบรรยายพิเศษภาควิชาวิศวกรรมเครื่องกล คณะวิศวกรรมศาสตร์ มหาวิทยาลัยมหิดล*

บทคัดย่อ

วัตถุประสงค์: เพื่อศึกษาการออกแบบ การสร้างหุ่นยนต์ต้นแบบทางคลินิกที่สามารถทำการเคลื่อนย้ายผู้ป่วยในโรงพยาบาล และสามารถทำการจัดท่าทางผู้ป่วยเพื่อการผ่าตัดในห้องผ่าตัดได้

วัสดุและวิธีการ: ด้วยความร่วมมือทางวิชาการและห้องปฏิบัติการระหว่าง Center for Biomedical and Robotics Technology (BART LAB) ภาควิชาวิศวกรรมชีวการแพทย์ คณะวิศวกรรมศาสตร์ และภาควิชาศัลยศาสตร์ คณะแพทยศาสตร์ โรงพยาบาลรามาธิบดี มหาวิทยาลัยมหิดล ในการออกแบบและวางแผนสร้างหุ่นยนต์บริการต้นแบบชื่อ "คลินิกคอน"

ผลการศึกษา: "คลินิกคอน" เป็นหุ่นยนต์บริการต้นแบบที่สามารถเคลื่อนย้ายและจัดท่าผู้ป่วยได้ตามเป้าหมายที่วางไว้

สรุป: "คลินิกคอน" เป็นหุ่นยนต์บริการทางการแพทย์ต้นแบบที่เคลื่อนที่เองตามแนวเส้นทางที่กำหนดถาวร โดยเฉพาะในห้องผ่าตัด และสามารถทำการจัดท่าผู้ป่วยได้ด้วยการควบคุมอีกขั้นตอนหนึ่ง

Corresponding Author: สรยุทธ ชำนาญเวช พบ.
หน่วยประสาทศัลยศาสตร์ ภาควิชาศัลยศาสตร์ คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี มหาวิทยาลัยมหิดล,
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คณะวิศวกรรมศาสตร์ มหาวิทยาลัยมหิดล Email: rasorayouth@mahidol.ac.th