Introduction to Mobile Robotics Lab.
(OTA Lab.)
2014

Human-Artifactology Research Division,
Research into Artifacts, Center for Engineering (RACE) 5F

The University of Tokyo
Kashiwanoha 5-1-5, Kashiwa, Chiba 277-8568, Japan

TEL:

Professor's room (509):		+81-4-7136-4252
Research Associate' room:		+81-4-7136-4272
Laboratory	(559, 561):	+81-4-7136-4260
	(534-A, B):	+81-4-7136-4276
FAX:		+81-4-7136-4242

URL: http://www.race.u-tokyo.ac.jp/otalab

Members

Professor	Jun OTA
Research Associate	Taiki OGATA
Project Researcher	Zhifeng HUANG, Dandan ZHU
Doctoral Course Students	Hiroki KATO Yusuke, Jorge David FIGUEROA HEREDIA, Ping JIANG, Nobutaka KIMURA
Master Course Students	Fusao OHASI, Kazuaki TSUJIMOTO, Takahiro KATAYAMA, Veerachart SRISAMOSORN, Sho Shiraishi, Sahloul Hamdi, Chingszu Lin
Undergraduate Students	Taku ITO, Naotaka MATSUI
Secretaries	Mika TAMURA, Ayako NAKAMURA

Research Topics of Mobile Robotics Lab. (OTA Lab.)

We have been studying multiple mobile robot systems since 1989. We consider intelligent systems as consisting of three factors: (a) multiple robots or intelligent machines (multiple agents), (b) human-beings who operate or cooperate with multiple agents, and (c) working environments. Now we deal with "multi-agent robotics and mobiligence", "design of large-scale production/transport systems", and "human analysis" based on motion planning methodology, evolutionally computation, control theory, and so on.

Our final target is to establish design methodology of multi-agent systems including artificial agents, humans and working environments through clarifying the function in intelligence and mobility (mobiligence) of these agents.

Semi-Direct Teaching Method for Grasping Objects in Service Mobile Robot Systems

A semi-direct teaching method for specifying information for grasping objects by mobile robots in home or office environments through the generation of a teaching data is proposed in this research. Information specified during the teaching process includes: object's shape, grasping force, grasping position, and orientation. To achieve this data indication in our approach, we propose the use of a teaching tool created by us and which has the same mechanism as the hardware (gripper) placed on the robot Pioneer 3 (Fig. 1). This enables our system to carry out the teaching process without using the robot. The challenging point is how to easily obtain information on shape, grasping force, grasping position, and orientation to be used as teaching data.

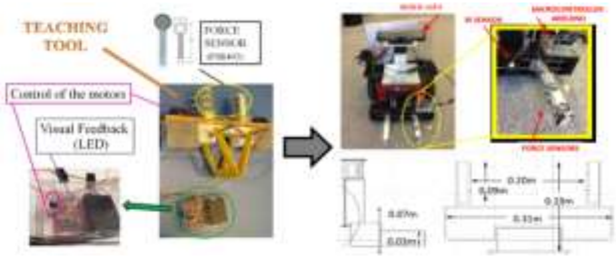
In the proposed method (refer to the flowchart Fig. 2), we use an RGB-D device to get information regarding the height (in meters) relative to the flat surface of the desk and the arm of our teaching tool. The system also provides us with information about how deep (in meters) the arm of our teaching tool went into the cube. With this information, part of the teaching data is generated.

In the teaching tool, we are using force sensors to obtain the measurement of applied force (in Newtons) by the teaching tool at the moment of grasping the object, and also to measure the stability of the object once it is lifted. An overview of the method approach is shown in Fig. 3. Our approach method was evaluated by using the data generated by the robots which performed the same task (grasping the object in the same position.) The experiment is shown in Fig. 4.

***Keywords*:** robot teaching, RGB-D sensor, grasping

Reference

FIGUEROA, Jorge, OTA, Jun, "Semi-direct Teaching Method for Grasping Objects in Service Mobile Robot Systems - Teaching Data Generation", IEEE international conference on Systems, Man, and Cybernetics (SMC), 2013, pages 2390 – 2395.



(a) Teaching tool (b) The service robot

Fig. 1 Teaching tool and the robot

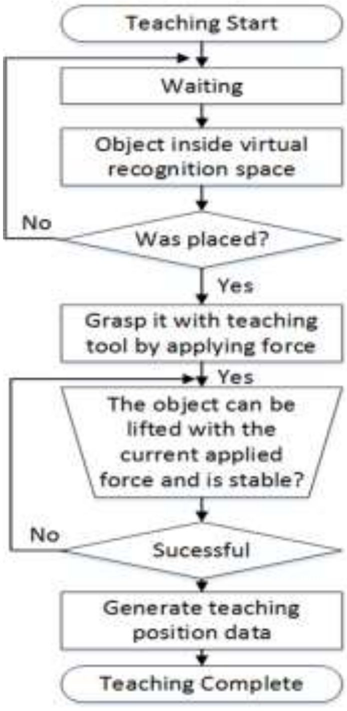


Fig. 2 Flowchart showing the process of teaching

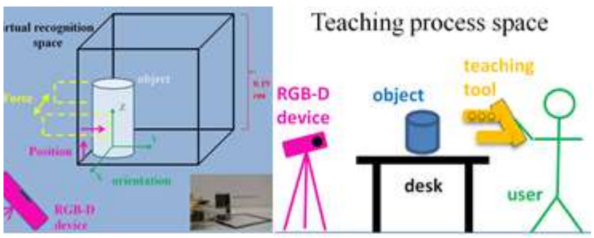


Fig. 3 Overview of the method approach

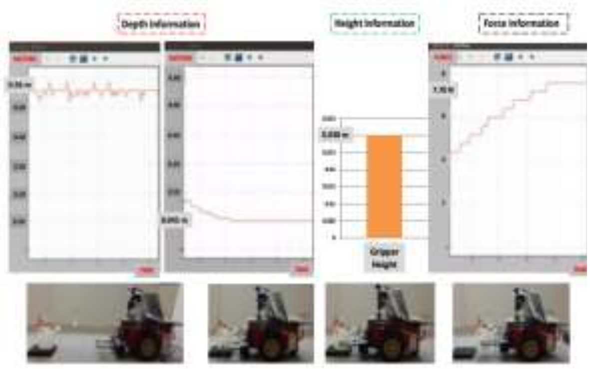


Fig. 4 Teaching data generation for the object

Transportation of a Large Object by Mobile Robots Using Hand Carts

A mobile robot is expected to perform a work on behalf of the human, owing to its wide range of movement. For example, there are transportation of objects in a factory and arrangement of objects in a house/office as the applications to be considered. Therefore, assuming the works mentioned above, the force needed to complete the work is greater than the force the mobile robot can provide, which is limited.

To transport a large object by small mobile robots, it is important to reduce the load on the mobile robots. As a solution to this problem, this research proposes a new methodology for transportation of objects by mobile robots through using hand carts.

In the proposed method, the object is loaded onto small hand carts by two mobile robots, as explained in the following steps. First, a robot equipped with an end-effector (robot A) tilts the object to provide the space between the object and the floor (Fig. 1). Then the other robot (robot B) inserts two hand carts into the provided space (Fig. 2). The robot A then moves to the opposite side of the object to tilt it again, and the robot B inserts the rest of the hand carts. In this process, the risks upon tilting the object are "fall of the robot by the reaction force of pushing an object" and "slip of the object already loaded onto the cart" (Fig. 3). To address these problems, for the former we proposed pressing the plate (put a stop to slip) against the floor with an air cylinder driving, and for the latter to prevent slippage of the robot (backward) when exerting force on the object, we are still thinking in a solution.

***Keywords*:** mobile robot, transportation, hand cart

Fig. 1 The robots and the hand cart

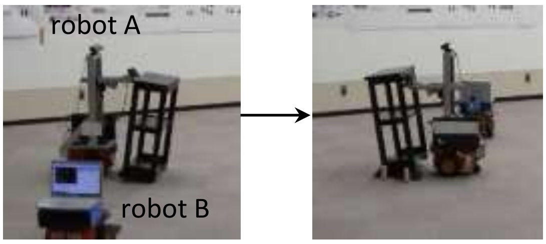


Fig. 2 Operation procedure

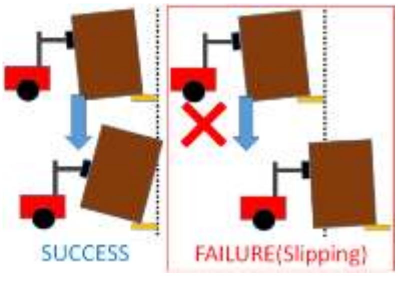


Fig. 3 A problem in tilting an object

Integrated Design of Multi-Robot System for Pick-and-Place Tasks

To improve the productivity, reduce the purchase cost, and apply a multi-robot system for a pick-and-place task quickly, the appropriate robot arms and their base positions should be rapidly selected. However, a large computational time is required to select the appropriate robot arms and their base positions because they are selected by the experienced engineers through evaluating the performance index in several trials.

In this study, we call the selection of robot arms and their base positions as integrated design of multi-robot system and propose a method (Fig. 1) to rapidly realize the integrated design of multi-robot system (Fig. 2). We use the multi-objective particle swarm optimization (MOPSO) to select appropriate robot arms from a set of candidate robot arms to make up an appropriate multi-robot system, use the particle swarm optimization (PSO) to search for the base positions of the robot arms, and use the *M/M/1* queuing model with impatient customer to estimate the performance index. A simulation proves that the proposed method is effective and efficient in comparison to a comparative method that uses simulation-based statistical inference to estimate the performance index. The robot arms and their base positions derived by the proposed method are similar to that derived by the comparative method. The computational time for the proposed method is 0.48 hour, which is less than 1/20 of the computational time for the comparative method (Fig. 3).

Keywords: integrated design of multi-robot system, MOPSO, PSO, *M/M/1* queuing model, pick-and-place task

Reference

[1] Y. J. Huang, R. Chiba, T. Arai, T. Ueyama, and J. Ota, Integrated design of multi-robot system for pick-and-place tasks, in Proc. IEEE Int. Conf. on Rob. and Bio., pp. 970-975 (2013)

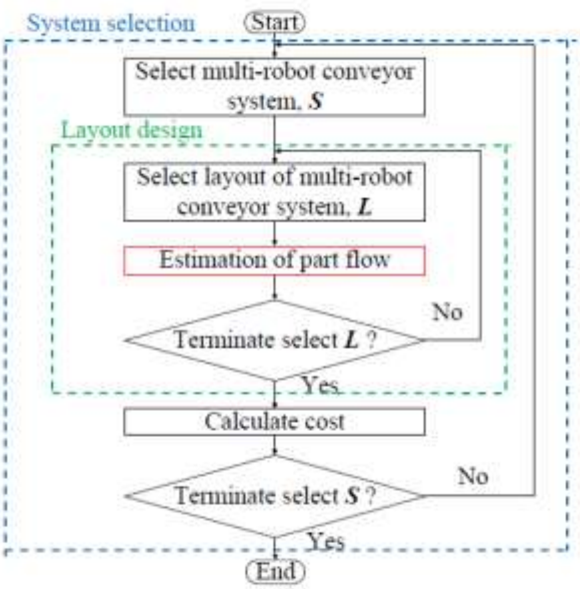


Fig. 1 Proposed method

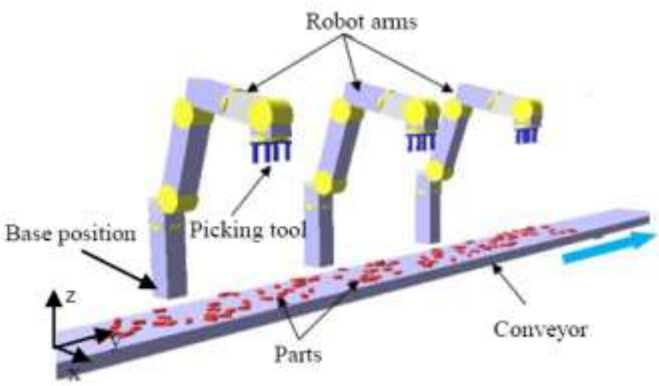


Fig. 2 A multi-robot system consists of multiple robot arms

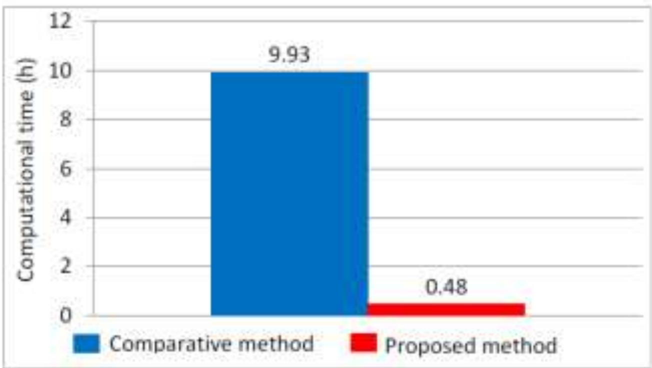


Fig. 3 Computational time for proposed method and comparative method

Generation of Image Recognition Procedures in Production Lines by Using Optimization Algorithm

In order to improve the productivity, reduce the production cost and other purposes, many tasks in the production line, such as the assembly task and the inspection task, are automated. For those tasks, the image recognition technique is used. It is necessary for image recognition to find recognition objects from images and then identify the objects from the criteria called feature. The procedure of image recognition is generally consisted by 3 steps; image conversion, feature extraction, and identification (Fig. 1). By appropriately designing these 3 steps, the process of image recognition works as expected. The experienced engineers design the steps, but they have a tough time because of several reasons; a huge amount of the combination of a step for image conversion, necessity to tune parameters of every step for image conversion, the difference of the criteria and those values, called identification dictionary, due to the difference of image conversion process, the fact that the adequacy of the designed procedure is only by whether the task is accomplished, and so on.

In this study, we take an example which to recognize the shape and the position of the objects in order to grasp the objects by the robots in the production line (Fig. 2), and propose a method (Fig. 3) to generate image recognition procedures by focusing only to image conversion parameters and identification dictionary. By giving the images of recognition objects instead of the identification dictionary to the computer, it can create an appropriate identification dictionary for every image conversion process. We optimize the image conversion parameters and identification dictionary. There are two objectives; first priority is to maximize recognition rate of shape, and second priority is to minimize the greatest value of position error. The proposed method shows good result from the view point of recognition rate in comparison to a comparative method that gives identification dictionary and so does not create it with respect to each generated image conversion process (Fig. 4).

Keywords: optimization, image recognition, parameter tuning, identification dictionary

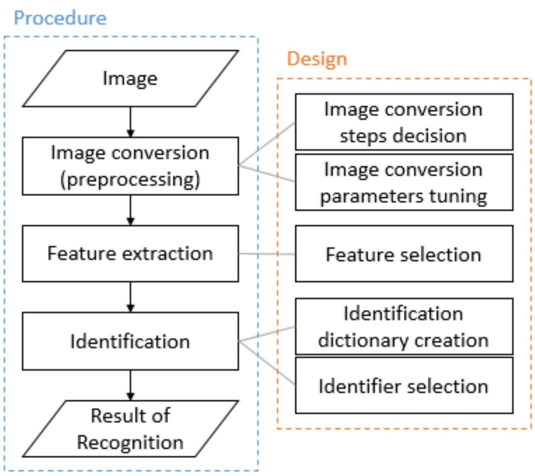


Fig. 1 Procedure and design of image recognition

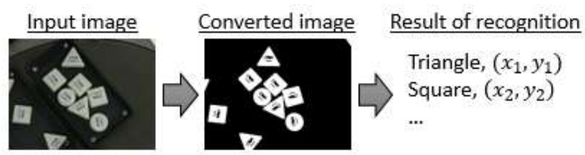


Fig. 2 Example task for image recognition

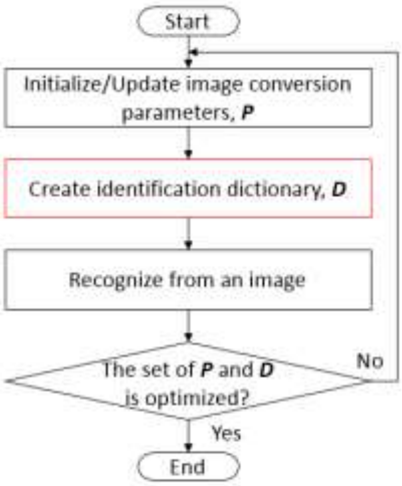


Fig. 3 Proposal method

Method	Evaluation index	
	Recognition rate (F-measure)	Maximum position error [pixel]
Proposed method	1	4.04
Comparative method	0.875	4.04

Fig. 4 Evaluation index for proposal method and comparative method

Temporal Co-creation between Multi-People

As evidenced in music ensemble, dance and sports, people cooperatively produce rhythm with other people. Such temporal co-creation between multi people includes many time delays: delays included in signal processing, multi-modal integration, sensory-motor coordination and cooperation with other people. Despite of such delays, people generate movement cooperatively with others in real time. To investigate the characteristics of temporal co-creation between people is important not only to understand human communication but also to achieve temporal co-creation between human and artifacts.

We conducted a psychological experiment. In the task, two mutually isolated followers simultaneously synchronized by finger tapping with a human leader or metronome producing constant tempo. The followers performed this task with or without tapping timing information of the other follower. The leaders were asked to tap their finger to keep constant tempo with or without the tapping time information of followers. Negative asynchronies (NAs) were observed under all leaders conditions. That is, the tap timings of the followers preceded those of the leaders. The amount of NA under human leader conditions was smaller than that under metronome condition. In addition, the followers predictively synchronized the human leaders while they synchronized the metronome to follow it up.

***Keywords*:** temporal co-creation, multi-people communication, cooperative rhythm production

References

T. Ogata, T. Katayama, Y. Miyake and J. Ota, Cooperative Rhythm Production between Three People through Auditory Signals. In Proceedings of 23rd International Symposium on Micro-Nano Mechatronics and Human Science, pp. 456—459, Nagoya, Nov. 2012.

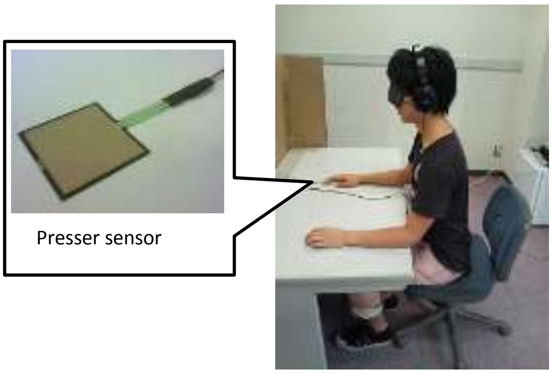


Fig. 1 The picture of a participant in the experiment and the presser sensor to measure the timing of the tapping

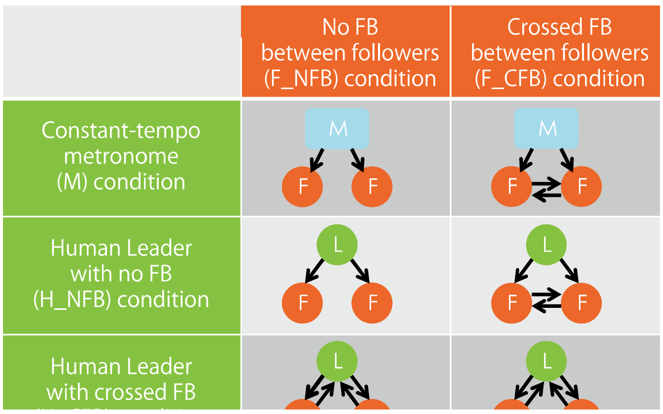


Fig. 2 The conditions of a leader who keeps the constant tempo and followers who cooperatively produce rhythm to synchronize with the leaders. The arrows indicate presentation of stimuli of metronome or other peoples' tapping timing. FB means feedback.

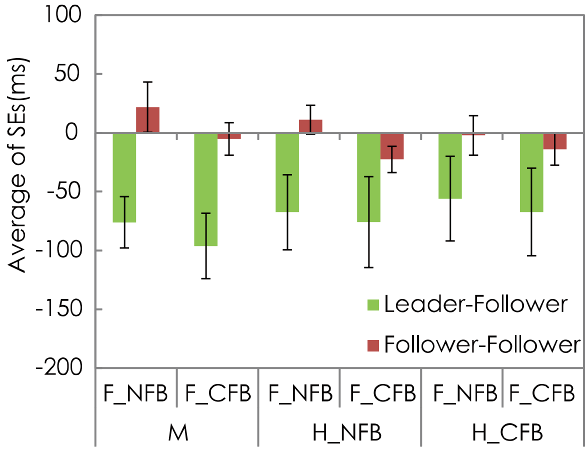


Fig. 3 Averaged synchronized errors (SEs). The followers tended to tap before the leaders.

Robot Patient for Nursing Training

In nursing care, there are many tasks involving moving the patient's body, such as bathing, giving assistance in dressing, etc. For the safety of nurses and patients, it is critically important for the nurses to accurately acquire these skills.

In order to improve the skills for nurses in such tasks, the mock patient is generally utilized in simulated training to reproduce the patient's performance. Generally, the mock patients are acted by the stationary manikins or the healthy people. However, such mock patients cannot precisely reproduce the real patients. For example, the stationary manikins cannot reproduce the movements of human's joints. On the other hands, for the healthy people, it is difficult to simulate the movements of the patient with decline of muscle strength and paralysis. From this viewpoint, developing a robot patient which could accurately reproduce the patients' limb movements and interact with the trainee would be great help for the nurses to improve their nursing skills.

Two types of robot patients were developed for the patient transfer and dressing training respectively. The former one was target on reproducing the patients' body limbs movement and interacting with the trainees during patient transfer (Fig. 1 and Fig. 2). The later one was targeted on reproducing the patients' upper limbs' joint's DOF and rotation range, in addition, measuring the joint's rotation angle for evaluating the trainees' skill performance (see Fig. 3 and Fig. 4).

Keywords: robot patient, nursing skill, skill acquisition

Reference

[1] Zhifeng Huang, et. al. "Design of a robot for patient transfer training," *In Proceeding of 2013 SICE Annual Conference*, Nagoya, 2013, pp. 246–254.

[2] Ayanori Nagata, et. al. "Mannequin robot to measure movement of patient's arm by nurse during exchange of the patient's wear on bed," *In Proceeding of 2014 JSPE Spring Conference*, Tokyo, 2014, pp. 895-896.

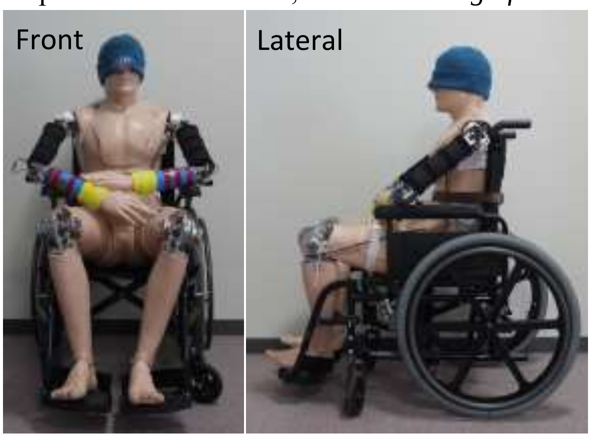


Fig. 1 Robot patient for patient transfer training

Fig. 2 Using robot patient in patient transfer training

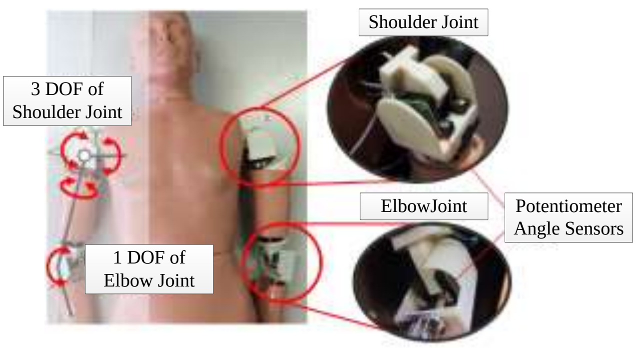


Fig. 3 Robot patient for dressing training

Fig. 4 Using robot patient in dressing training

Patient Robot Emulating Different Symptoms

Nurses have to perform nursing operations according to diverse patient's symptoms. For example, changing nightclothes is a kind of nursing operation which is affected by patient's whole body symptoms (Fig.1). Currently healthy people or mannequins are performing as a mock patient for nursing's training purpose. However, it is a problem that such mock patients are not suitable for nursing students to learn nursing operations according to diverse patients because they are not able to perform diverse patient's symptoms.

To solve the problem, we study to use a patient robot which can emulate different symptoms. We focused specifically on paralysis. Paralysis is a major symptom because it is caused by apoplexy. So, there are many cases where nurses treat patients with paralysis. Moreover, there are different paralysis conditions. One type is the spastic paralysis, which stiffens paralyzed body parts. Another type is the flaccid paralysis, which slackens paralyzed body parts. Thus, various types of paralysis should be considered when treating patients.

To emulate different symptoms of paralysis by a robot, we must imitate the whole human body. We try to construct a mechanism which can emulate both types: spastic paralysis and flaccid paralysis. So far, we made a prototype of a robot's elbow and tested its performance (Fig.2). In the future, we will make other joints of the robot to finally integrate it into an education system for nursing operation training by using patient robot.

Keywords: nursing operation, education system, patient robot, different symptoms

Fig. 1 Changing nightclothes

Fig. 2 Prototype of robot's elbow

Activity-Aware Topic Model

In everyday life, we keep receiving recommendations from others either by words of mouth, press print, or multi-media such as TV advertising. Nowadays, recommender systems are entering our life online: advertising about something you searched the other day in Google appears in the right side of your current searching page; Amazon always tries to guess what you would be interested in and give some similar items as recommendations; content sites such as StumbleUpon provide information in particular areas which you set before.

This research will serve for recommender systems by focusing on capturing people's activities from tweets to find the associated preference topics. Such recommender system is supposed to provide more targeted information with accompanied comprehensive recommendations. The research priority is to build a categorized database for the reference of activity-aware topics. The tri-layer clusters are expected, which consist of a general topic layer, a detailed activity layer and a word layer. Fig. 1 gives two specific examples of the expected tri-layer clusters. The data source is twitter posts, and we propose two topic models to generate the tri-layer clusters.

Reference

[1] Zhu D, Fukazawa Y, Karapetsas E, et al. Activity-based topic discovery[J]. *Web Intelligence and Agent Systems*, 2014, 12(2): 193-209.

[2] Dandan Zhu, Yusuke Fukazawa, and Jun Ota, Estimation of User's Activity from Tweets through Tri-Layer Clustering Model, *Proc. of the Seventh International Conference on Mobile Computing and Ubiquitous Networking*.

[3] Zhu D, Fukazawa Y, Ota J. Tri-Layer-Cluster Generation Model for Activity Prediction[C], *Proc. of the 2013 IEEE/WIC/ACM International Joint Conferences on Web Intelligence (WI) and Intelligent Agent Technologies (IAT)*, 359-366, 2013.

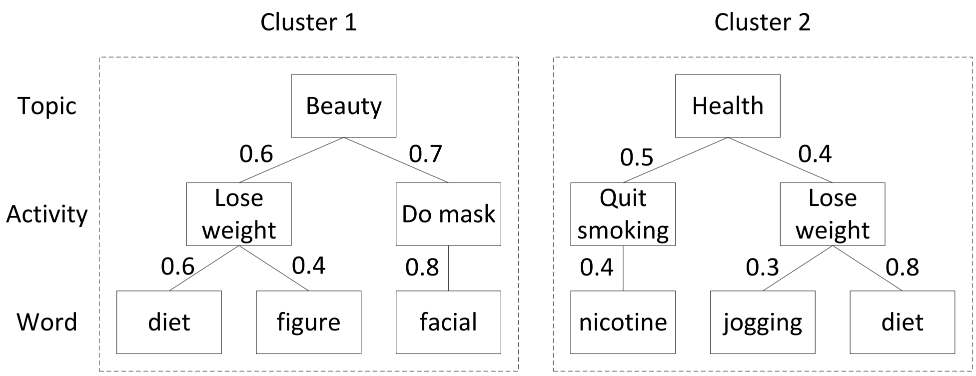


Fig. 1 Tri-layer clusters

Modeling of Standing Postural Control

Clarification of standing postural control mechanism makes significant contribution to understandings of nervous system and planning of treatment for neurological patients. Physiological researchers presented qualitative postural control models for quadrupedal walking based on experiments, but whether it also correspond to human stance postural control mechanism is not clear. On the other hand, engineering researchers always adopted an inverted pendulum model which neglected the muscles of humans.

Our objective is to validate whether the postural control model for quadrupedal stance of animals can also keep human standing; and to investigate the influence of feed-forward control on the postural control based on a musculoskeletal model with enough muscles.

We proposed two hypotheses:

1. Human postural control mechanism is composed of both feed-forward and feedback muscle tonus modulation control, as shown in Fig. 1.
2. The feed-forward control has a function of improvement of postural stability

To validate hypothesis 1. We increased delay time by 10ms increments to check whether FF and FF+FB can keep the musculoskeletal model standing when delay is 100ms.

To validate hypothesis 2. Under a certain delay, we compared the stability index (sway of joint) between FF+FB and FB to investigate which leads to better postural stability.

As a result, we found that both FB and FF+FB are able to keep the musculoskeletal model standing, implying that postural mechanism might consists of them. However, system including FF will have better stability, as shown in Fig. 2. Such a kind of function of stability improvement was supposed to result from the working of reticulospinal tract. We will improve our control model and try to validate it based on some experimental data.

Keywords: postural control, musculoskeletal model, biological simulation

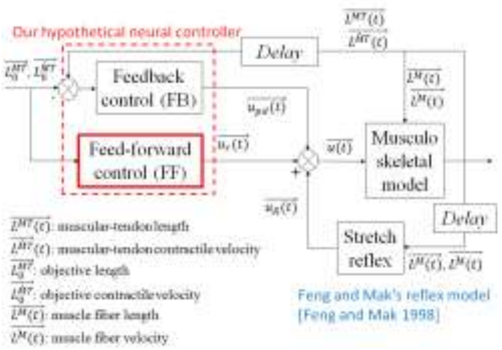


Fig. 1 Stance postural control model

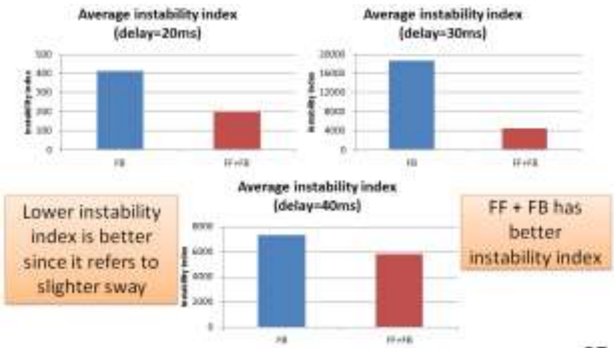


Fig. 2 Stability index

Gait Analysis of Decerebellate Rats
for Evaluation of Site Specificity of Cerebellar Dysfunction

Cerebellar dysfunction is one of the main causes of motion disorder. In order to relieve the symptom, it is necessary to clarify fundamental cerebellar functions, which will also contribute to the diagnoses, prophylaxes, treatments and rehabilitation of cerebellar dysfunction. And, it is known that cerebellum has a site specificity of function. Clinical cases and animal experiments of animals that have lesions of cerebellum shows that lesion of each area of cerebellum causes different symptoms. However, information about site specificity of cerebellum is incomplete. Especially, there are few studies about how the dysfunction of different area of cerebellum will affect motor function during walking.

In this study, we evaluated the effect of site specificity of cerebellar motor dysfunction of partially decerebellate rat. We presented the hypothesis that disorder of each area of cerebellum causes abnormal posture, decreased muscle tone, lowering movement velocity and influence on emotion function. To validate it, as shown in Fig. 1, we conducted experiments where we made rats, whose medial area or lateral area of cerebellum has been removed, walking a treadmill. We measured the motion and EMG of extensor muscles of their limbs, especially the angles between their limbs and plane when toe off (Fig. 2), their movement velocity on treadmill and voluntary locomotor activity. The results indicated that rats which have removal of medial area show abnormal motion of hindlimbs and rats which have removal of bilateral area show no abnormal motion of their limbs, but rats which have removal of bilateral area and posterior medial area show abnormal motion of forelimbs.

***Keywords*:** decerebellation, site specificity of cerebellar function, gait analysis of slope walking, posture control

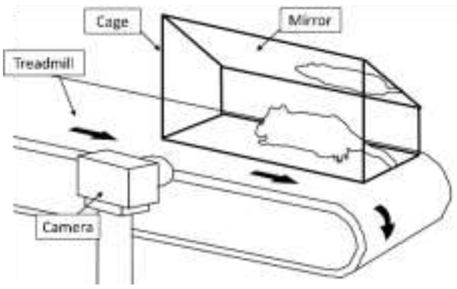


Fig. 1 Equipment of experiment.

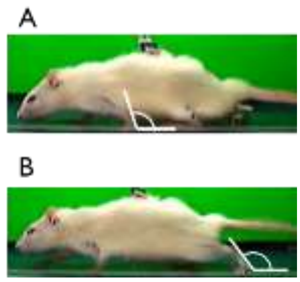


Fig. 2 Measurement of motion of limbs

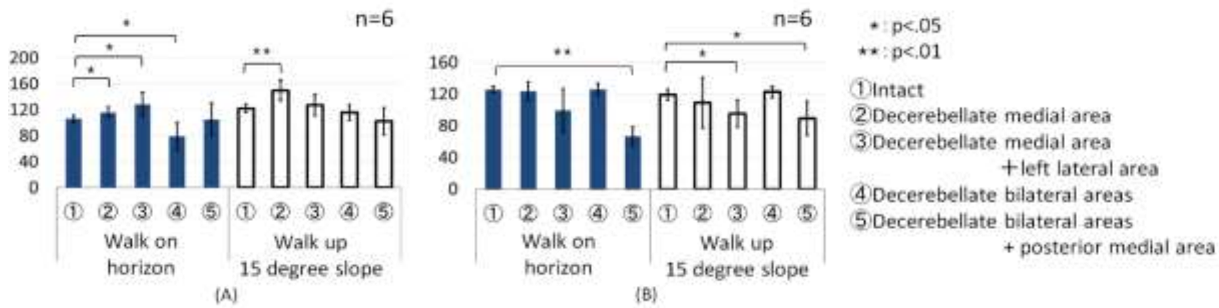


Fig. 3 Measurement of angle between each limb and plane when toe off (A) forelimb (B) hindlimb