Introduction to the Mobile Robotics Lab
(OTA Lab)
2015

Human-Artifactology Research Division,
Research into Artifacts, Center for Engineering (RACE) ,
The University of Tokyo

Research Complex 5F, Kashiwa Campus,
Kashiwanoha 5-1-5, Kashiwa, Chiba 277-8568, Japan

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

Members

Professor	Jun OTA
Research Associate	Taiki OGATA
Postdoc Researchers	Shohei SHIRAFUJI, Jose RUBRICO
Doctoral Course Students	
	Jorge David FIGUEROA HEREDIA, Ping JIANG, Nobutaka KIMURA
Master Course Students	
	Veerachart SRISAMOSORN, Takahiro KATAYAMA, Takumi SHIRAISHI, Hamdi SAHLOUL, Jingsi LIN, Taku ITO, Naotaka MATSUI
Undergraduate Students	
	Daigo YUKISAWA, Yuuri TERADA
Secretaries	Mika TAMURA, Ayako NAKAMURA

Research Topics of the 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, evolutionary computation, control theory, and so on.

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

Teaching of Multiple Robots by a Human

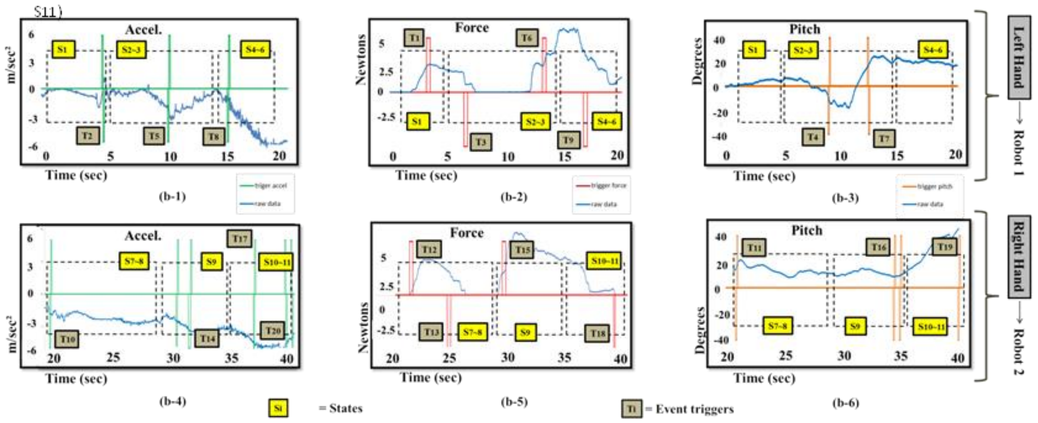
A service system composed of small robots which are able to do tasks executed by a single human in environments like homes or offices. The goal is that a user will be capable of teaching multiple small robots how to perform tasks. We use kinematic data during the teaching process like the motion and force applied by the hands of the subject during task execution. Based on the analysis of the data generated versus the physical capabilities of the robots, the system determines how many robots will execute the task and how to split it into subtasks for each robot.

Figure 1 shows the teaching process for an “unfolding chair” task. First (Fig. 1(a)) in a sequence of images it is shown how a single human performs the opening of the chair which is initially lying on the floor. Then, the teaching data generated during the demonstration is shown (Fig. 1(b)). Finally, it is shown (Fig. 1(c)) how the information will be used to decide the number of robots and their programming among which to divide the work.

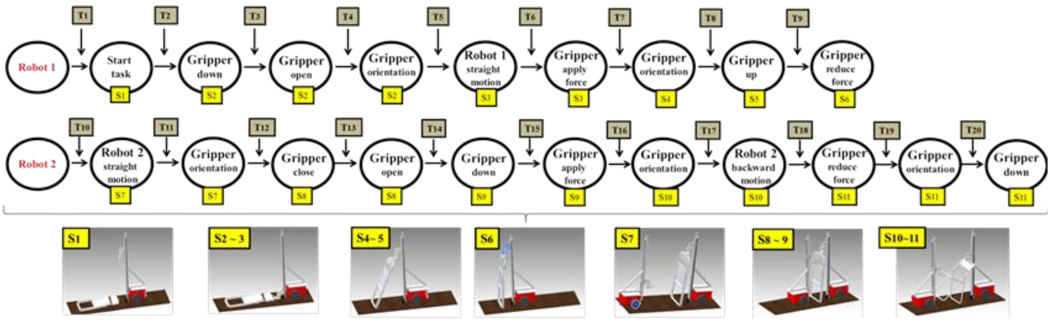
Reference

[1] FIGUEROA, Jorge, SAHLOUL, Hamdi, OTA, Jun, ”Teaching Multiple Robots by a Human - Teaching Data Generation -”, IEEE international conference on Robotics and Biomimetics (ROBIO), 2014, pages 2121 – 2126, Bali, Indonesia.

(a) **Demonstration:** Single human performing the task with a folding chair to generate teaching data. Eleven states are indicated (S1 ~ S11)



(b) **Teaching data generated through sensors:** data generated by the left hand (b-1, b-2, b-3) is used to program the robot 1and data generated by the right hand (b-4, b-5, b-6) is used to program the robot 2. The teaching data contains the raw data and the event triggers (T1 ~ T20), which are used to generate movements that robot should do. The time period in which the states occur is also



(c) **How we expect to use the information:** the work was divided between two robots because the operating range exceeds the capabilities of one robot. To exemplify our method for this experiment we assigned manually the motion that each robot has to perform. The state change that causes each trigger is indicated by using “Ti” and “Si”.

Fig. 1. Experiment: Teaching multiple robots how to open a folding chair by a single human.

Automatic Face Tracking System using Quadrotors for Estimation of Elderly People's Emotion

For health care provided to elderly people or people with some mental disorders, patients' emotions need to be observed regularly. The current practice uses a number of staff to observe their faces and use smile as the indicator. However, the ratio of staff to patients is not enough and the task require regular observation, resulting in inefficiency, ineffectiveness, and fatigue of the caregivers. Therefore, a system for tracking people's faces and processing of their emotions is necessary for this task. This research proposes the use of environmental cameras together with mobile cameras to track people's faces to obtain their facial images.

In the proposed method, quadrotors equipped with small video cameras are used to follow and track people's faces (Fig. 1), where the facial images can be sent back and the emotion estimation can be performed. Xbox 360's Kinect cameras are installed in the environment to cover the area and detect the positions and orientation of each person in the space. The position and direction of the head is then used to set up the goal position for the quadrotor such that it is at a distance in front of the person and pointing the camera towards the face. The quadrotor's position is also detected from the depth image provided by the Kinect sensors, while its orientation is obtained from the onboard inertial measurement unit (IMU). Finally, the quadrotor is navigated to the goal position, where the camera can capture the person's facial images. Fig. 2 displays the tracking process in action for tracking of one person using one Kinect and one quadrotor, with the quadrotor flying in the top left corner of the image.

Keywords: quadrotor, Kinect, human tracking, face tracking

Reference

[1] Srisamosorn, V., Kuwahara, N., Yamashita, A., Ogata, T., and Ota, J. "Automatic Face Tracking System using Quadrotors: Control by Goal Position Thresholding". *Proceedings of the IEEE International Conference on Robotics and Biomemetics (ROBIO 2014)*, pp. 1314-1319, Dec 2014.

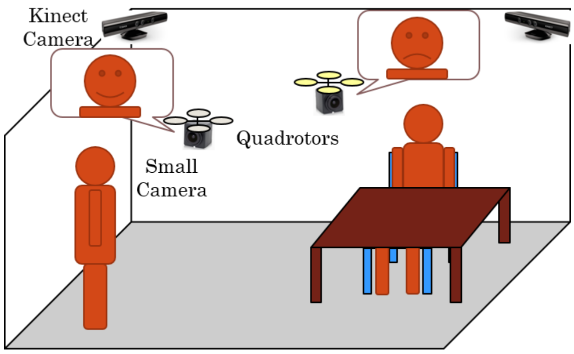


Fig. 1. System of quadrotors in elderly nursing home.

Fig. 2. Quadrotor tracking the person's face.

Design of image recognition procedures in a manufacturing system using optimization algorithm

Image recognition techniques are often used in manufacturing systems. Image recognition includes finding objects from images and identification of the objects by the feature criteria. The procedure of image recognition generally consists of three steps: image conversion, feature extraction, and identification (Fig. 1). In these three steps, there is a huge amount of design factors: the various image conversions and combinations of them, multiple parameters in each image conversion and the criteria, and those values included in the identification dictionary. Furthermore, it makes the design difficult that the designed procedure is evaluated by the task that is accomplished using the procedure. Therefore, only experts can design the image recognition procedure, which prohibits the wider progress of image processing in manufacturing systems.

We took an example, which is to recognize the shape and the position of objects in order to grasp those objects using robots in the production line (Fig. 2), and propose a method (Fig. 3) to generate image recognition procedures by focusing only on 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 the identification dictionary and so doesn't create it with respect to each generated image conversion process (Fig. 4).

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

Reference

[1] K. Tsujimoto, *et al.*: "Simultaneous Design of Image Conversion Parameters and Classifier in Object Recognition for a Picking Task," Proc. Int. Conf. Robotics Biomimetics (ROBIO2014), pp. 457-462, 2014.

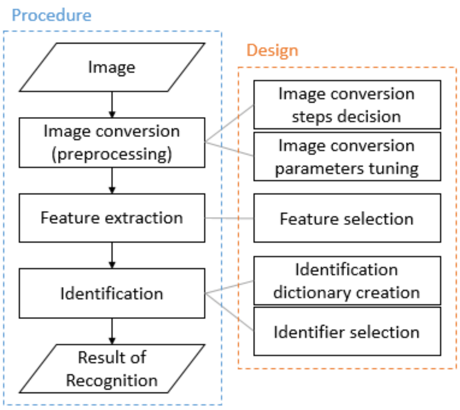


Fig. 1. Procedure and design of image recognition.

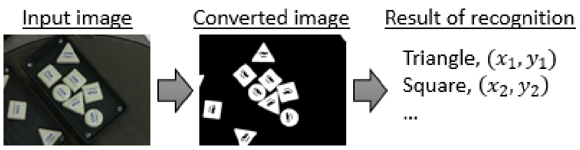


Fig. 2. Example task for image recognition.

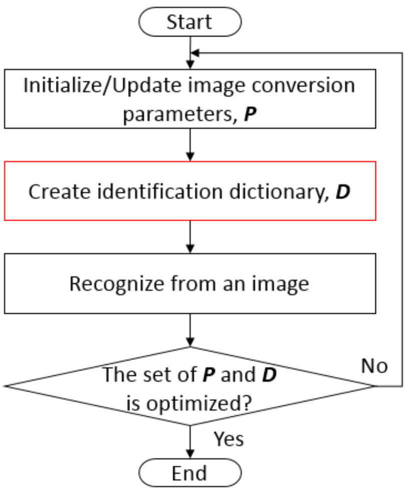


Fig. 3. Proposed method.

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 proposed and comparative methods.

Temporal Co-creation between Multi-People

As evidenced in music ensembles, 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 humans and artifacts.

We conducted a psychological experiment. In the task, two mutually isolated followers are 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 conditions. In addition, the followers predictively synchronized with the human leaders while they synchronized with the metronome to follow it up.

***Keywords*:** Temporal co-creation, Multi-people communication, Cooperative rhythm production

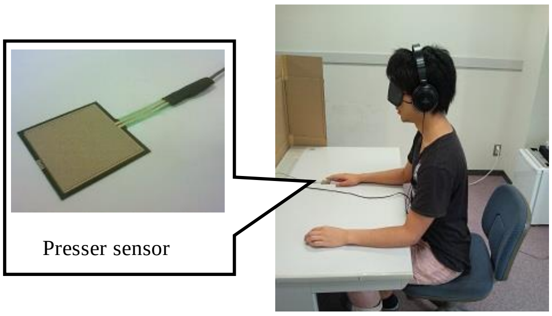


Fig. 1. A participant in the experiment and the presser sensor tos measure the timing of the tapping.

References

[1] 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.

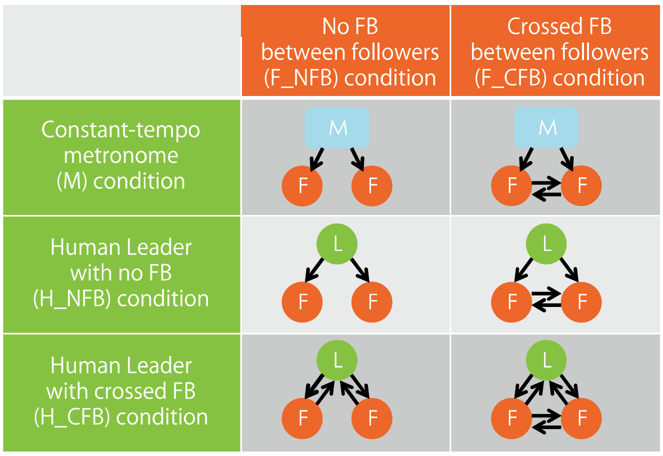


Fig. 2. The conditions of a leader who keeps the constant tempo and followers who cooperatively produce rhythm to synchronize with the leaders. The arrows indicate presentation of stimuli of metronome or other peoples' tapping timing. FB means feedback.

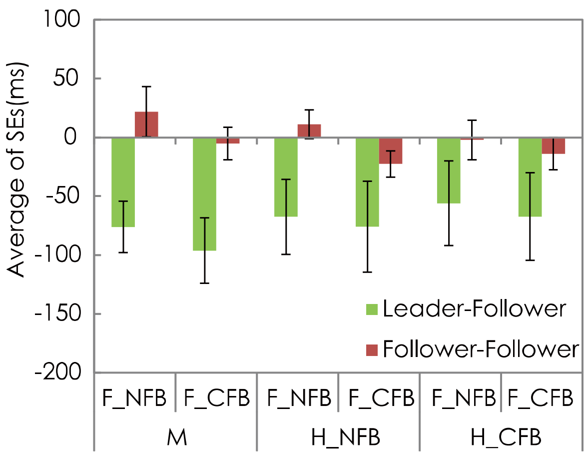


Fig. 3. Averaged synchronized errors (SEs). The followers tended to tap before the leaders.

Robot Patient for Nursing Training

In nursing care, there are many tasks that involve moving the patient's body, such as assistance in bathing and dressing. To improve the skills of nurses, mock patients in the form of stationary manikins or healthy people are generally utilized to simulate the performance of patient care. However, such mock patients cannot precisely represent the real patients. For example, the stationary manikins cannot reproduce the movements of human joints. For healthy people, it is difficult to simulate the movements of patients with deteriorated muscle strength and paralysis. To develop a robot patient which could accurately reproduce a real patient's limb movements and interact with the trainee would be a great help for the nurses in improve their caregiving skills.

Two types of robot patients are developed for patient transfer and dressing training, respectively. The former one is geared towards reproducing a patient's limb movements and interacting with the trainees during patient transfer (Fig. 1 and 2). While the latter is aimed at reproducing a patient's upper limb joints' DOF and rotation range, and in addition, measuring the joints' rotation angles for evaluating the trainee's skill (see Fig. 3 and Fig.4). Furthermore, we aim to construct a mechanism which can simulate two types of paralyses: spastic and flaccid paralysis (Fig. 5).

Keywords: Robot patient, Education system, Nursing skill, Skill acquisition, Paralysis simulation

Reference

[1] Zhifeng Huang, et.al. "Robot patient for nursing self-training in transferring patient from bed to wheel chair," Proc. HCI International 2014, Crete, pp. 246–254, 2014.

[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," Proc. 2014 JSPE Spring Conference, Tokyo, pp. 895–896, 2014.

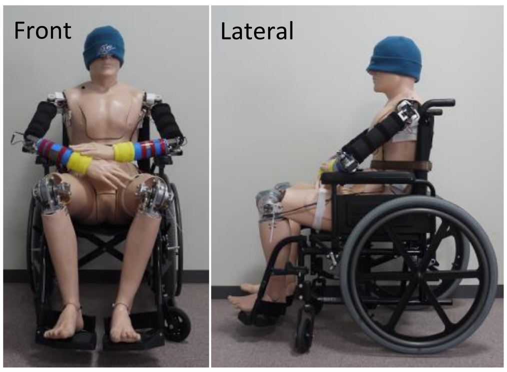


Fig. 1. Robot patient for patient transfer training.

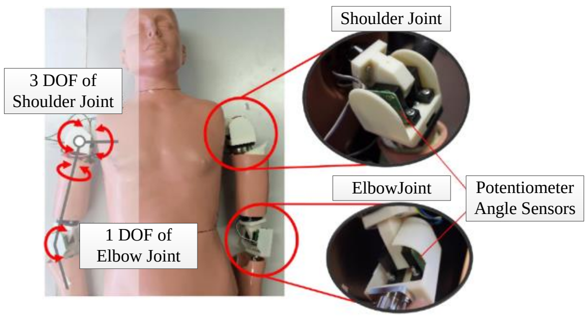


Fig. 3. Robot patient for dressing training.

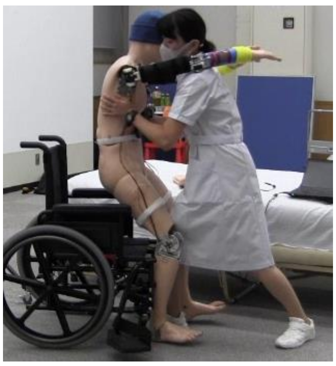


Fig. 2. Using robot patient in patient transfer training.

Fig. 4. Dressing training using robot patient.

Fig. 5. Prototype of robot's elbow.

Stance postural control in consideration of neurological time delay based on a musculoskeletal model

To understand complicated stance postural control mechanism, realization of biped stance motion of a musculoskeletal model which is controlled by a physiologically plausible neural controller is important. Most previous studies adopted an inverted pendulum model to represent the human body, neglecting the complexity of the human musculoskeletal system. Furthermore, neurological time delay, which has great influence on posture stability, was neglected and should be investigated more deeply.

In this research, we focus on the human musculoskeletal system and neurological time delay, which are two important elements in posture control. We proposed a neural controller (Fig. 1) to keep a musculoskeletal model with 70 muscles standing under 100ms delay. Through forward dynamics simulation, we validated whether the proposed controller could keep the musculoskeletal model standing. In the future, we will investigate the influence of feed-forward control, one of the components of a neural controller besides feedback control, on postural stability.

Keywords: Postural control, Musculoskeletal model, biological simulation

References

[1] Jiang, Chiba, Takakusaki, Ota: Stance postural control of a musculoskeletal model able to compensate neurological time delay, In Proc. Int. Conf. Robot. Biomim. (ROBIO 2014), pp.1130-1135, 2014.

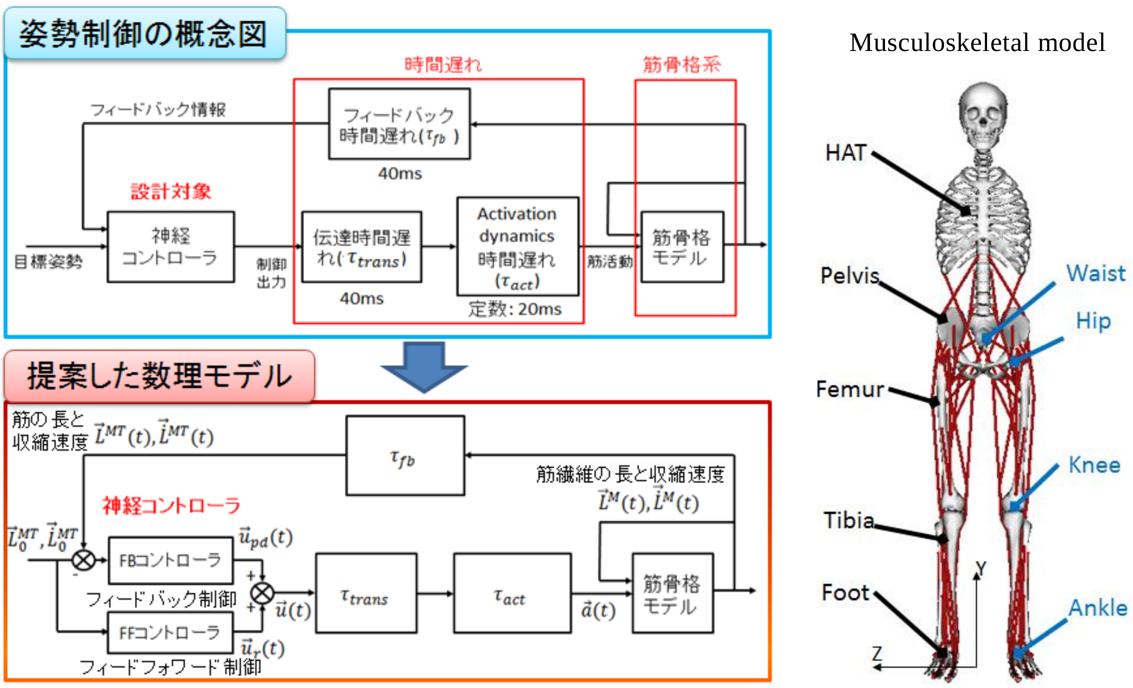


Fig.1. Stance postural control model.

Quantitative Evaluation of Gait Disturbance by Ablating Different Cerebellar Areas in Rats

Cerebellar dysfunction is one of the main causes of movement disorder. Patients who have cerebellar dysfunction especially suffer from serious gait ataxia. Diagnoses, prophylaxes, treatments and rehabilitation of cerebellar dysfunction still lack efficiency due to our limited understanding of fundamental cerebellar functions. Therefore, clarifying fundamental cerebellar functions is necessary. Clinical cases and experiments have shown that the cerebellum has a site specificity of function. Animals that have lesions in different areas of the cerebellum will have different symptoms. However, information about site specificity of the cerebellum is insufficient. There are few studies about how the dysfunction in different areas of the cerebellum will affect motor function during walking and few quantitative data on the symptoms of gait ataxia. Thus, quantitative evaluation of symptoms of gait ataxia resulting from dysfunction in different parts of the cerebellum is important.

In this study, we propose methods for quantitative evaluation of influences of dysfunctions in different specific cerebellar areas on gait disturbance by experiments on partially decerebellate rats. Physiological studies showed that dysfunctions in the cerebellum will cause abnormal posture, decreased muscle tone, lowered movement velocity, influence on emotional function and disequilibrium. To investigate the relationship between site specificity and those symptoms, as shown in Fig.1, we conducted experiments where we made rats, whose medial area or lateral area of cerebellum had been removed, walk on a treadmill. We measured the motion of their trunk and limbs (Fig.2) and extensor muscle EMG of the limbs, especially the knee angles of mid-stance, their movement velocity on the treadmill, voluntary locomotor activity and trembling of the trunk. As a result, there are significant differences of the knee angle of mid-stance between Sham-operated rats and some decerebellate rats: four rats out of five with removed medial area, two rats out of three with removed bilateral area, and two rats out of two with removed medial and bilateral areas (Fig.3). The result indicates the feasibility of quantitative evaluation of decreased muscle tone with measurement of joint angles.

Keywords: Cerebellar Gait Ataxia, Ablation, Site Specificity of Cerebellum, Posture Control

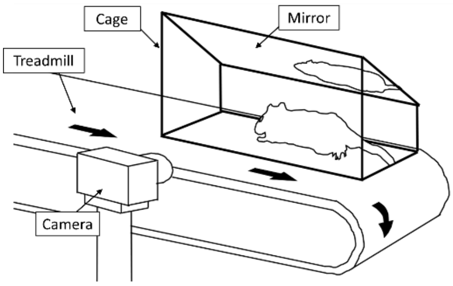


Fig. 1. Illustration of walking experiment.

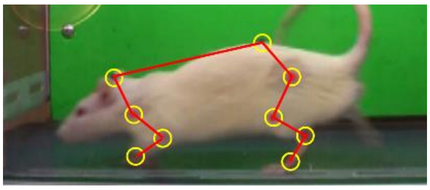


Fig. 2. Tracking of motion of joints in rat.

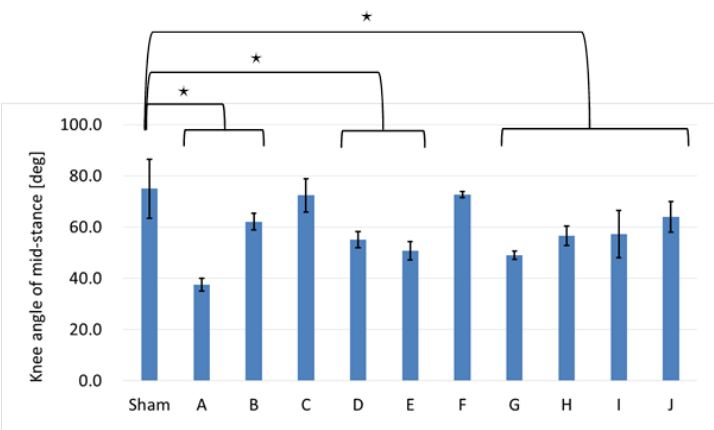


Fig.3. Measurement of knee angle when mid-stance. A-E: removal of medial area. F-H: removal of bilateral area. I-J: removal of medial and bilateral area. Values are shown as means ±SE. *$P < 0.05$. All averages are made from 4–12 steps.

Topic Models Considering Weather Context

In everyday life, we keep receiving recommendations from others either by word-of-mouth, press print, or multi-media such as TV advertising. Nowadays, Amazon always tries to guess what you would be interested in and give some similar items as recommendations. In order to make these recommendation systems， developers need to predict users’ interests. POS data is the simplest way to know them, but not all service providers can get POS data.

Then, there are some researches to predict users’ interests from micro blogs such as Twitter. Those researches use models called “Topic Model” to classify words into some topic cluster because the same words can sometimes pertain to different objectives (For example, the intended object of the phrase “lose weight” could either be “beauty” or “health”). Furthermore, since users’ topics change owing to weather context, we aim to “research the relationship between weather context and content posted on Twitter using topic models”. We show an example of the relationship between weather-context and topics, and the relationship between topics and words in Fig. 1, and results in Fig. 2.

***Keywords*:** context-aware, recommendation, topic model, weather-context, Twitter

Reference

[1] 伊藤 拓, 深澤 佑介, 朱 丹丹, 太田 順, Tweet内容に影響を与える気象条件と特徴語の抽出, 情報処理学会, 2014-MBL-73, No.1, 2014.

[2] Taku Ito, Yusuke Fukazawa, Dandan Zhu and Jun Ota, Climate Condition that Mostly Affects the Change of the Tweet Content, International Conference on Mobile Computing and Ubiquitous Networking (ICMU2015), 20 Jan 2015.

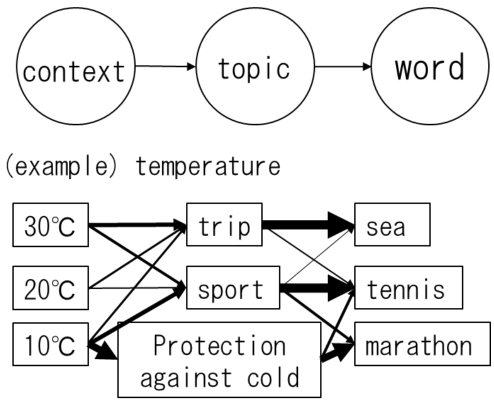


Fig. 1. Relationship between temperature-context, topics, and words.

About 22℃ September

words	weighting factor
ヨーグルト	0.150690
ピッツァ	0.082197
食パン	0.068498
サバ	0.068498
漬物	0.054799

About 28℃ September

words	weighting factor
抹茶	0.191786
牛肉	0.123292
かき揚げ	0.095895
ハチミツ	0.082197
ソフトクリーム	0.041101

Fig. 2. Topic clusters of different weather.