https://doi.org/10.20965/jaciii.2017.p0330

Paper:

Using Finger Dexterity in Elderly and Younger People to Detect Cognitive Decline

Katsuya Fujiwara, Hiroyuki Fujii, and Kazutaka Mitobe

Graduate School of Engineering Science, Akita University
1-1 Tegata-gakuen-machi, Akita 010-8502, Japan
E-mail: fujiwara@ie.akita-u.ac.jp

[Received May 19, 2016; accepted November 30, 2016]

Because the number of elderly people is rapidly growing, using information and communication technology (ICT) for services to watch single-elder-person households has been attracting attention. Most of these services are aimed at detecting elders' abnormalities. They could become more effective, from the preventive-medicine point of view, if additional functions were added to watch for any decline in the elders' cognitive functions. In this paper, we describe a method for detecting minor declines in elders' cognitive functions, which they may not be aware of, by measuring and analyzing their spiral-tracing ability using a tablet device. We developed such a measurement/analysis system and applied it to three groups of test participants: young, non-frail elders, and frail elders. This paper first describes the method for analyzing the numbers of out-of-orbit tracing attempts, the numbers of uncompleted attempts, the required time, and the angular velocities, and then refers to these tasks to reveal the elders' characteristics from the analytic results.

Keywords: finger dexterity, cognitive assessment, physical function assessment, monitoring elders, tablet device

1. Introduction

As the elderly population is rapidly growing [1–3], there is an increasing demand for detecting their cognitive abnormalities, especially when they live alone. Services to watch them using information and communication technology (ICT) have become more and more popular as part of home security [4–8]. Such technologies, however, are mainly designed to detect abnormalities related to elders' life crises by monitoring whether or not they are active at home; they are not designed to detect declines in the elders' cognitive functions. Thus, several cases have occurred where a family that lived far away only noticed a problem when the elder's dementia was significantly advanced. Under the circumstances, it would be more useful, from the perspective of extending their healthy life expectancy, to add functions that monitor the elders' cognitive functions to the existing watching services. In particular, those with asymptomatic cerebral infarctions do not usually show any symptoms that will adversely affect their daily lives; however, depending on the infarction sites, they may be exposed to the risk of accumulating minor effects on their perception, memory, judgment, etc. As their age advances, the number of sites affected by asymptomatic cerebral infarctions increases, increasing their risk of developing symptomatic cerebral infarctions or dementia later on [9–12]. As asymptomatic cerebral infarctions can be detected by brain-imaging diagnoses with magnetic resonance imaging and/or computerized tomography, medical brain checkups should be effective for such people. If we could promote medical brain checkups using tests at home or other simple methods, it could lead to the early detection of asymptomatic cerebral infarctions.

Thus, we propose a testing system using a tablet device to be operated at home by the elders themselves [13], which could detect any decline of their cognitive functions, present the test results simply and clearly, and encourage them to get a medical brain checkup. Thus far, we have built a basic measuring system using a tablet device to measure detailed time-series data on their handwriting [14]. In this study, we aim to reveal the elders' cognitive characteristics by measuring their finger dexterity in tracing a spiral figure displayed on the tablet screen. If we could apply such measurements to assess their motor and cognitive functions, we could expect that continuous, periodic measurements could lead to early detection of such functional declines.

2. Assessments by Spiral-Tracing Tasks

Numerous methods for testing the fingers' dexterity have been proposed, and used to check for neurological disorders and impaired motor functions [15, 16]. It is also reported that declines in the fingers' dexterity are linked to declines in the cognitive functions [17, 18]. In this study, we have paid special attention to the spiral-drawing tests, among the various finger-dexterity tests that elders can easily take at home.

Spiral-drawing tests involve tracing a spiral drawn on a sheet of paper and have been adopted to test the upper limbs' dexterity at clinical sites [19, 20]. Parkinson's

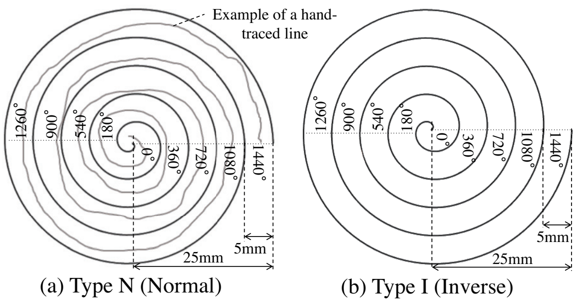


Fig. 1. Spiral type N (clockwise from inside to outside) and type I.

Fig. 2. Measurement environment.

Table 1. Six types of tasks.

Task	$N+$	$I+$	$N-$	$I-$	NL	$N10$
Spiral type	N	I	N	I	N	N
Start[deg]	0	0	1440	1440	1440	1440
Goal[deg]	1440	1440	0	0	0	0
Additional instruction					The ink is transparent.	Please try to do this within 10 sec.

disease progression rates can be visually diagnosed by trembles in the handwriting that reflect the shaking upper limbs. An automatic diagnosis for this disease using a liquid-crystal tablet device has also been recently developed [21, 22]. Such spiral-drawing tests with no time limit would be easy for a healthy person to accomplish if they took them slowly and steadily, such that no visual differences in their handwriting could be observed [23]. This study, aimed at detecting minor declines in the cognitive functions of healthy persons with no subjective symptoms, has set the following conditions to make the spiral-drawing task more difficult.

(a) Draw a spiral without crossing the lines bordering a 5-mm-wide space.

(b) Draw a spiral as fast as possible.

The above-mentioned conditions for the spiral-drawing task, in which participants attempt to trace a 5-mm-wide space instead of a fine line, are intended to encourage the participants to draw as quickly as possible, rather than tracing slowly and steadily along the line.

3. Purpose and Objects of Measurements

Figure 1 illustrates the spiral figures used for the measurements. In the spiral-drawing task, the participant uses a stylus pen to trace a spiral-shaped 5-mm-wide blank space without crossing the black spiral lines, while their handwriting data, which contain their fingers' dexterity characteristics, are recorded. **Fig. 1(a)** shows an example of a participant's handwritten spiral line. The spiral figure's curvature becomes larger as it nears the center, so more minute motions are required of the fingers at this point. Larger motions are required of their wrists and arms as they progress farther from the spiral center. Thus, we can duly expect that such spiral-drawing tasks will enable us to measure a variety of dexterity characteristics as the participants draw small to large arcs. **Fig. 2** shows a measurement scene.

To determine a method by which we could easily reveal elders' characteristics, we conducted measurements five times for each of the six types of spiral-drawing tasks shown in **Table 1**. Using the two spiral types with different spiral directions, as shown in **Figs. 1(a)** and **(b)**, we first established four spiral-drawing tasks: tasks to trace a spiral from inside to outside ($N+$, $I+$) and tasks to trace from outside to inside ($N-$, $I-$). Then, based on the $N-$ task, we established the NL task, in which the handwriting is not displayed on the screen, and the $N10$ task in which the participants are instructed to complete it within ten seconds. The task order performed by each participant was decided using the Latin square design [24] to diminish any learning effects. The following four instructions were given to the participants:

(1) Draw a line with a stylus pen without touching the black lines.

(2) Draw a line from the starting point to the finish point.

(3) Draw a line as fast as possible.

(4) Draw a line with a single stroke of the pen.

The test participants were classified into the following three groups:

- Young Group: 10 persons (20 to 23 years of age)

- Non-Frail Elders Group: 11 persons (61 to 81 years of age)
- Frail Elders Group: 6 persons (77 to 92 years of age, HDS-R (Revised Hasegawa's Dementia Scale [25, 26]) = 3 to 28), including two persons with Alzheimer's dementia, one person with senile dementia, two persons with a suspected case of dementia, and one person with long-term care needs.

All of the participants were right-handed. The young participants and non-frail elderly participants made 30 attempts per person against 15 attempts by each frail elder. To alleviate any measurement burden on the frail elders, they performed a subset of the tasks, $N+$, $N-$, and NL, and when they could not complete a task, they gave it up.

We used an active type of stylus pen with a fine nib to give the users a sense of use closer to a ball-point pen. The tablet device used for measurements had a 7-inch touch panel with a 213-dpi resolution. The handwriting data were sampled at a rate of about 60 Hz.

Dementias, are generally classified by the cause, have some common symptoms caused by the decline in cerebral function. The frail-elders group included a few persons without dementia, a few persons with suspected dementia, and a few persons with different kinds of dementia, which made it difficult for us to individually derive any statistical outcome. However, all the participants in the frail-elders group were certified as needing long-term care and commonly had evident symptoms in their cognitive or motor functions. Thus, we noted any differences in such symptoms between the healthy persons and the frail elders.

4. Analytic Method and Results

4.1. Analyses of Out-of-Orbit Scores and Uncompleted Tasks

In all of the six tasks, where the participants were asked to trace a 5-mm-wide space bordered by black lines, their handwriting occasionally touched or crossed the black lines. By counting how many times their handwriting crossed the black lines and returned in one tracing attempt, their out-of-orbit scores (O^3 scores) were recorded. When some of the participants gave up their tracing attempts in the middle and did not reach the finish point, the O^3 scores were recorded as N/A (not applicable). When some of the frail-elderly participants determined that they would never be able to reach the finish point and aborted their attempts, such uncompleted attempts were also recorded as N/A. **Fig. 3** shows the aggregate results of the O^3 scores.

All of the young participants succeeded in reaching the finish point, complying with all of their instructions; thus, no N/A attempts were counted. The young participants' zero-O^3 scores (i.e., no deviations) account for the largest percentage (83.7%) in the I− task, and the second largest percentage (82.0%) in the $N+$ task.

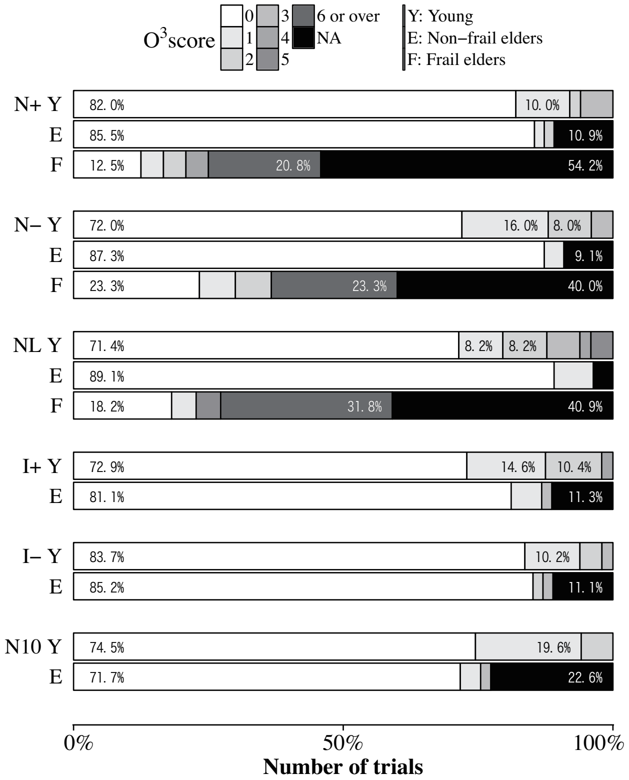


Fig. 3. O^3scores for each trial.

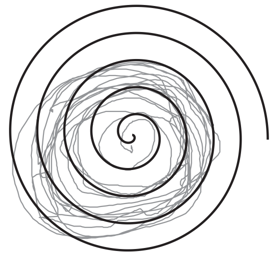


Fig. 4. Uncompleted $N+$ task by a participant in the frail-elders group.

The non-frail elder participants have some N/A attempts in every task. Specifically, N/A attempts account for 22.6% in the $N10$ task, twice as many as those in the $N-$ task, where N/A attempts account for 9.0%. The non-frail elder participants have the fewest N/A attempts in the NL task (3.6%).

The frail-elder participants' N/A attempts account for more than 40% in every task, and 54.2% in the $N+$ task. **Fig. 4** shows an example of an uncompleted (N/A) $N+$ task: an attempt by a frail-elder participant (with Alzheimer's dementia, HDS-R = 3), in which the participant began drawing a circle from the inside, determined that he would never be able to complete the drawing, and gave it up; all of his tasks for drawing a circle from the inside are N/A attempts. The frail elders have fewer zero-O^3 scores than the other participant groups, and such zero-crossing attempts only account for 12.5% in the $N+$ task.

Four of the six frail-elder participants achieved O^3 scores of N/A or 1 or more, with no zero-O^3 scores, in all of their attempts.

We discuss the O^3-score characteristics of the three participant groups in Subsection 5.1. Although differences between the young and non-frail elders are clearly recognizable in the O^3 scores, in the following subsections, we discuss other analytic methods that could better reveal both groups' characteristics.

4.2. Analysis of Required Time

The time required by the participants to trace a spiral constitutes one of the important indices for measuring their work rates per unit time. The time required for one tracing attempt is measured from the time their handwriting passes the starting point until the time when it passes the finish point. When measuring the required time, uncompleted (N/A) attempts are omitted because they cover shorter distances and require a shorter time than the completed attempts.

Figure 5 shows the mean time required by the participants to complete each task, together with the standard deviations. The t-tests show significant differences in the mean average required time between the young participants and the non-frail elder participants. In the $N10$ task, where the participants were instructed to complete a drawing task within 10 seconds, 90% of the young participants completed the task within 10 seconds on average, while 27% of the non-frail elder participants did so.

Figure 6 shows the mean time required to complete the tasks with O^3 scores of 0, or 1 or more, together with the standard deviations. Both the young participants and the non-frail elder participants required a significantly longer average time to complete the tasks with a zero O^3-score.

4.3. Analysis of Angular Velocities

As an index by which we can compare the dexterity in more detail than the required time, we determined the pen nib's angular velocity at each degree of the spiral figure drawn in **Fig. 1**, based on the handwriting data comprised of a set of timestamps and XY coordinates. We only analyzed the data on the pen nib's angular velocities in the normal direction from the start to the goal and omitted any data on the handwriting in the reverse direction. We only analyzed the data on the attempts that completed the tasks with zero-O^3 scores. **Fig. 7(a)** shows the angular velocities in the six tasks attempted by the young participants. In the four tasks that start from outside the spiral, or 1440 deg, the handwriting reaches a maximum angular velocity at around zero degrees and the second peak at around 150 deg; in the $N10$ task, the second peak value is 559.5 deg/s at 148 deg. The above-mentioned characteristics are not recognizable in the data for the non-frail elder participants. In the $N10$ task by the young participants, the angular velocities reached the highest at the 82.6% range of angles in all six tasks.

Figure 7(b) shows the non-frail elders' angular velocities in the six tasks: in the $N10$ task, their angular velocities are the highest at an 86% range of angles including 31 to 1115 deg in all of the six tasks; the maximum angular velocity in the $N10$ task is 472.0 deg/s at 68 deg.

The young participants and the non-frail elder participants showed some common characteristics: In the $N+$ and $I+$ tasks, where the handwriting starts from the inside, the angular velocities tended to decrease more at angles larger than 180 deg inside the spiral than in other tasks.

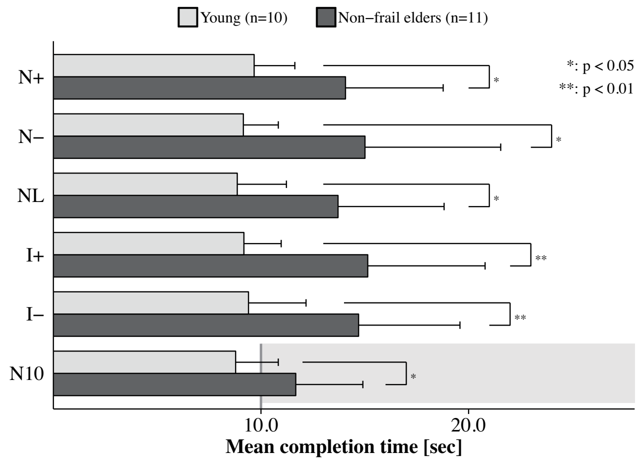


Fig. 5. Mean task-completion time.

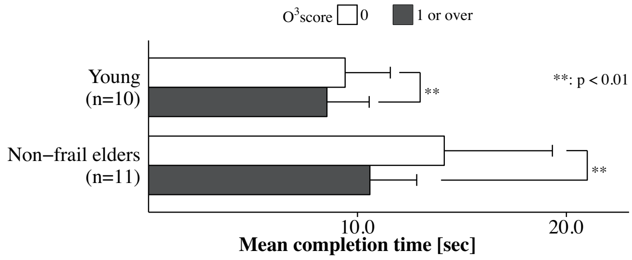


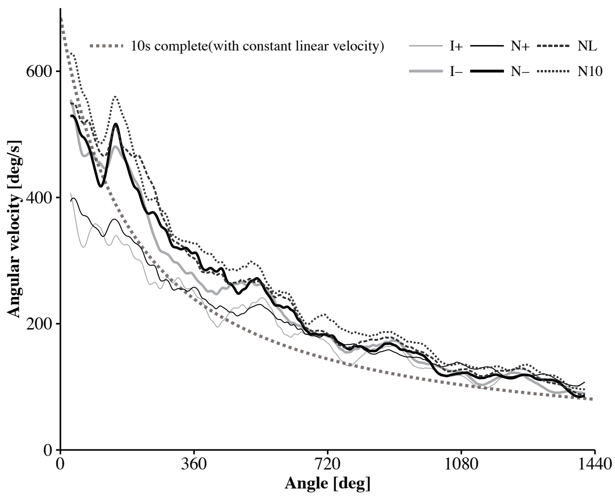
Fig. 6. Task-completion time and O^3 score.

5. Discussion

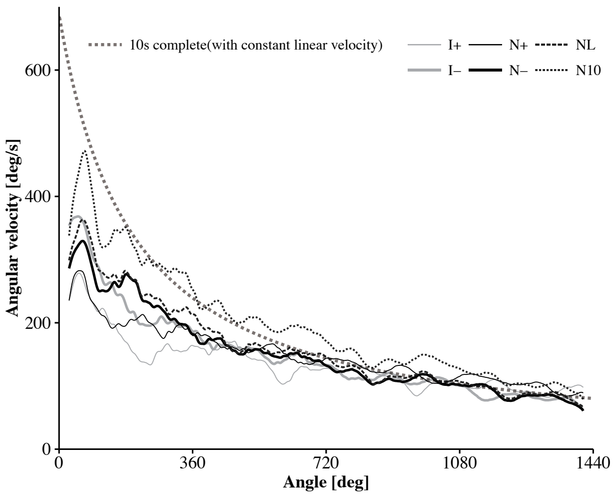
5.1. Characteristics of O^3 Scores of Young, Non-Frail Elders, and Frail Elders

The frail elders' O^3 scores show that their N/A attempts account for more than 40% of all the tasks and that they have fewer zero-O^3 attempts than the other participant groups in all the tasks. We note from the above-mentioned test results that the tracing tasks show significant differences in O^3 scores between the frail-elders group and the other two participant groups.

The young participants had no N/A attempts counted as O^3 scores; they fully complied with the instructed conditions until the finish point. The young participants' zero-O^3 score attempts account for the highest percentage in



(a) Young ($n = 10$)



(b) Non-frail elders ($n = 11$)

Fig. 7. Angular velocity of each task.

the $I-$ task (83.7%) and the second highest percentage in the $N+$ task (82.0%). The participants draw a clockwise arc in the $I-$ and $N+$ tasks and counterclockwise in the other four tasks. Given that people from different cultures are accustomed to different ways of drawing a circle, tests with both Japanese and German participants showed that the Japanese participants tended to draw a circle clockwise from the bottom to the top, while the German participants drew counterclockwise from the top to the bottom [27]. The fact that the participants in this study are all Japanese, who are rather accustomed to drawing a curve clockwise than counterclockwise, could explain why the numbers of the participants' attempts completed without deviating from the designated space are the largest in the $I-$ and $N+$ tasks. Testing with participants from different cultures and analyzing such test results remain as issues to be addressed in future work.

The non-frail elders had some N/A attempts in every task. In particular, their N/A attempts account for 22.6% of the attempts in the $N10$ task, which represents more than twice as many N/A attempts than in the $N-$ task (9.0%). This could be attributed to the condition specific to the $N10$ task that the participants must complete the drawing task within 10 seconds: they may have given priority to shortening the required time and pressed ahead with the task, compromising the task quality. On the other hand, the non-frail elders have the smallest number of N/A attempts in the NL task, which accounts for 3.6%. In the NL task, where the drawn orbit is not displayed, the participants do not receive feedback on their drawing directions or velocities, which could significantly alleviate any burden on the non-frail elders, resulting in the above-mentioned decrease in N/A attempts in the NL task.

5.2. Characteristics of Time Required by Young and Non-Frail Elders

A comparison by tasks, except for the $N10$ task, shows that the largest number of participants required the shortest time in the NL task, where the handwriting was not displayed. Thus, they were not bothered by any visual feedback, so they might have been less concerned about touching or crossing the spiral lines when increasing their writing velocities.

Generally, taking sufficient time to draw a line carefully should make a precise and accurate orbit, which should also apply to any type of drawing task. In any attempts counted as O^3 scores of 1 or more, the participant may have prioritized shortening the time required to complete the tasks, while somewhat neglecting the instructions not to deviate from the designated space. Therefore, we compiled the mean required time and standard deviations for the attempts counted as O^3 scores of 0 and 1 or more, as shown in **Fig. 6**. It shows that both the young and non-frail elder participants required a significantly longer mean time to complete their tasks with no deviations.

5.3. Angular-Velocity Characteristics of Young and Non-Frail Elders

The length of a spiral line per degree becomes shorter as it nears the center. Therefore, as the pen nib moves along a spiral line at a constant linear velocity, its angular velocity increases as it nears the center. **Fig. 7** shows the angular velocities when the participants have drawn a line, together with a broken line for the angular velocities of the 10-s complete (with constant velocity) attempt. The 10-s complete attempt is when an ideal person have drawn a line at a constant velocity (31.5 mm/s) in the middle of the 5-mm-wide space (for a total length of 315.0 mm) in just ten seconds. Ten seconds is the instructed time limit of the $N10$ task. The angular velocities of both the young and non-frail elder participants are the highest at the widest range of angles in the $N10$ task, of all of the six tasks, as described in Subsection 4.3.

A comparison of angular velocities between the 10-s complete and the $N10$ task by the young participants shows that their angular velocities in the $N10$ task are higher at every angle than in the 10-s complete. The non-frail elders' angular velocities in the $N10$ task are lower than in the 10-s complete at angles below 216 degrees inclusive, between 373 deg and 396 deg, and above 1410 deg inclusive, and are remarkably lower than the young participants in the $N10$ task, especially in the space nearer the spiral center. This may be attributed to the elders' lack of dexterity in drawing a line with a tight curvature near the spiral center.

6. Conclusion

We proposed a method to analyze elders' dexterity by measuring spiral-tracing tasks using a tablet device as a method to detect minor declines in their cognitive functions. We developed a new measurement/analysis program to measure six kinds of tasks attempted by three groups of participants – young, non-frail elders, and frail elders – and analyzed the numbers of their out-of-orbit attempts, uncompleted attempts, required time, and angular velocities, to prove that the developed program can reveal distinctive differences between the above-mentioned groups. An especially noteworthy finding is that, while the young participants had no uncompleted attempts, the non-frail elders had 3.6% to 22.6% of uncompleted attempts in the six tasks, and the frail elders had over 40%. The analysis of the time required for the $N10$ task with a time limit showed that the ratios of the participants who completed the task within 10 seconds on average were 90% of the young participants and 27% of the non-frail elders: a significant difference in the mean required time. This analysis seems to suggest the effectiveness and easiness of the $N10$ task in detecting minor declines in the cognitive functions.

As the developed system can be operated with an affordable, generic tablet device available at ordinary homes, we hope that the knowledge acquired in this study can effectively be used in one-elderly-person households to daily monitor any changes in their dexterity and extend their healthy life expectancy as well. On the other hand, we are concerned that the developed method will not be applicable in its current state to watch elders with already shaking hands. We need to widen its application range by devising more methods, e.g., by combining it with other testing methods.

In the future, we plan to continue periodically monitoring the same test participants to determine a new monitoring method by which we can detect medium- to long-term functional declines.

Acknowledgements

This study was approved by the local ethics committee of Akita University and informed consent was obtained from each participant. This work was supported by JSPS KAKENHI Grant Number 16K00226.

References:

[1] Department of Economic and Social Affairs, United Nations, World Population Prospects: The 2015 Revision, United Nations publication, 2015.

[2] Cabinet Office, Government of Japan (Ed.), Annual Report on the Aging Society: 2015, Nikkei Printing, 2015 (in Japanese).

[3] National Institute of Population and Social Security Research, Government of Japan, Household Projections for Japan by Prefecture: 2010-2035, Population Research Series, No.332, 2014 (in Japanese).

[4] M. Marschollek, S. Mix, K.-H. Wolf, B. Effertz, R. Haux, and E. Steinhagen-Thiessen, "ICT-based health information services for elderly people: Past experiences, current trends, and future strategies," Medical Informatics and the Internet in Medicine, Vol.32, No.4, pp. 251-261, 2007.

[5] H. J. Lee, S. H. Lee, K.-S. Ha, H. C. Jang, W.-Y. Chung, J. Y. Kim, Y.-S. Chang, and D. H. Yoo, "Ubiquitous healthcare service using Zigbee and mobile phone for elderly patients," Int. J. of Medical Informatics, Vol.78, No.3, pp. 193-198, 2009.

[6] T. Koike, T. Fukaya, K. Nonaka, E. Kobayashi, M. Nishi, Y. Murayama, R. Watanabe, S. Shinkai, and Y. Fujiwara, "Usage conditions and intentions to use monitoring services for the elderly living alone," Japanese J. of Public Health, Vol.60, No.5, pp. 285-293, 2013 (in Japanese).

[7] P. Rashidi and A. Mihailidis, "A Survey on Ambient-Assisted Living Tools for Older Adults," IEEE J. of Biomedical and Health Informatics, Vol.17, No.3, pp. 579-590, 2013.

[8] L. Liu, E. Stroulia, I. Nikolaidis, A. Miguel-Cruz, and A. Rios Rincon, "Smart Homes and Home Health Monitoring Technologies for Older Adults: A Systematic Review," Int. J. of medical Informatics, Vol.91, pp. 44-59, 2016.

[9] S. E. Vermeer, M. Hollander, E. J. van Dijk, A. Hofman, P. J. Koudstaal, and M. M. B. Breteler, "Silent Brain Infarcts and White Matter Lesions Increase Stroke Risk in the General Population: The Rotterdam Scan Study," Stroke, Vol.34, American Heart Association J., pp. 1126-1129, 2003.

[10] S. E. Vermeer, N. D. Prins, T. den Heijer, A. Hofman, P. J. Koudstaal, and M. M. B. Breteler, "Silent Brain Infarcts and the Risk of Dementia and Cognitive Decline," The New England J. of Medicine, Vol.348, pp. 1215-1222, 2003.

[11] S. E. Vermeer, W. T. Longstreth Jr., and P. J. Koudstaal, "Silent Brain Infarcts; A Systematic Review," Lancet Neurology, Vol.6, No.7, pp. 611-619, 2007.

[12] I. Goldberg, E. Auriel, D. Russell, and A. D. Korczyn, "Microembolism, Silent Brain Infarcts and Dementia," J. of the Neurological Sciences, Vol.322, (1-2), pp. 250-253, 2012.

[13] H. Fujii, K. Fujiwara, and K. Mitobe, "The Simple Self-diagnosis System of Asymptomatic Cerebral Infarction using a Tablet Device for Elderly Monitoring," Tohoku-Section Joint Convention Record of Institutes of Electrical and Information Engineers, Japan, Vol.2014, p. 2I12, 2014 (in Japanese).

[14] H. Fujii, K. Fujiwara, and K. Mitobe, "Dexterity Analysis for Simple Self-diagnosis of Asymptomatic Cerebral Infarction using a Tablet Device," IPSJ Tohoku Branch SIG Technical Report, Vol.2014-1, No.6, pp. 1-6, 2014 (in Japanese).

[15] C. J. Golden, P. Espe‐Pfeifer, and J. Wachsler‐Felder, "Neuropsychological interpretations of objective psychological tests," Springer Science & Business Media, 2000.

[16] H. Shiraishi, "What is Evaluating Hand Functions – Various Evaluation Methods Related to Hands –," J. of the Society of Biomechanisms, Vol.34, No.4, pp. 291-296, 2010 (in Japanese).

[17] M. Sakamoto, E. Kikuchi, and M. Shigeta, "Relationship between Hand Dexterity and Severity of Dementia in Alzheimer's Disease: Changes in Handedness Superiority in the Course of Progression," Japanese J. of Rehabilitation Medicine, Vol.44, No.7, pp. 391-397, 2007.

[18] A. Tsuboi, M. Momma, Y. Kouno, et al., "Relationship between Hand Dexterity and Cognitive Function in Healthy Normal Subjects," J. of Health and Welfare Statistics, Vol.60, No.1, pp. 10-16, 2013 (in Japanese).

[19] P. Trouillas, T. Takayanagi, et al., "International Cooperative Ataxia Rating Scale for pharmacological assessment of the cerebellar syndrome, The Ataxia Neuropharmacology Committee of the World Federation of Neurology," J. of the Neurological Sciences, Vol.145, No.2, pp. 205-211, 1997.

[20] J. D. Schmahmann, R. Gardner, J. MacMore, and M. G. Vangel, "Development of a Brief Ataxia Rating Scale (BARS) Based on a Modified Form of the ICARS," Movement Disorders, Vol.24, No.12, pp. 1820-1828, 2009.

[21] J. Westin, S. Ghiamati, M. Memedi, et al.:"A new computer method for assessing drawing impairment in Parkinson's disease," J. of Neuroscience Methods, Vol.190, No.1, pp. 143-148, 2010.

[22] M. E. Isenkul, B. E. Sakar, and O. Kursun, "Improved spiral test using digitized graphics tablet for monitoring Parkinson's disease," ICEHTM 2014, pp. 171-175, 2014.

[23] T. Yoshii, Y. Matsumoto, S. Hirakawa, et al., "A basic study of tremor evaluation system development using spiral drawing task," IEICE Technical Report, Vol.MBE2005-67, pp. 47-50, 2005 (in Japanese).

[24] B. J. Winer, R. B. Donald, and M. M. Kenneth, "Statistical principles in experimental design," Vol.2, McGraw-Hill, 1971.

[25] S. Katoh, H. Simogaki, A. Onodera, H. Ueda, K. Oikawa, K. Ikeda, Y. Imai, and K. Hasegawa, "Development of the Revised Version of Hasegawa's Dementia Scale (HDS-R)," Japanese J. of Geriatric Psychiatry, Vol.2, No.11, pp. 1339-1347, 1991 (in Japanese).

[26] Y. Imai and K. Hasegawa, "The Revised Hasegawa's Dementia Scale (HDS-R)-Evaluation of its Usefulness as a Screening Test for Dementia," Hong Kong J. of Psychiatry, Vol.4, No.2, pp. 20-24, 1994.

[27] M. Taguchi, "Cultural differences in drawing movements between right-handed Japanese and German participants," Psychological Reports, Vol.107, No.1, pp. 329-335, 2010.

Name:
Katsuya Fujiwara

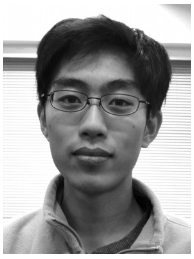
Affiliation:
Graduate School of Engineering Science, Akita University

Address:
1-1 Tegata-gakuen-machi, Akita 010-8502, Japan

Brief Biographical History:
1999/2002 Received the M.E., and the Ph.D. degrees in engineering from Meiji University, respectively
2002- Joined Akita University
2007- Assistant Professor, Akita University

Main Works:
• His research interests include human-centered computing, software engineering and network software.

Membership in Academic Societies:
• The Institute of Electrical and Electronics Engineers (IEEE) Computer Society
• The Institute of Electronics, Information and Communication Engineers (IEICE)
• Information Processing Society of Japan (IPSJ)
• Japan Society for Software Science and Technology



Name:
Hiroyuki Fujii

Affiliation:
Graduate School of Engineering and Resource Science, Akita University

Address:
1-1 Tegata-gakuen-machi, Akita 010-8502, Japan

Brief Biographical History:
2012/2014 Received the B.E., and the M.E. degrees from Akita University, respectively
2012 Received the incentive award of the IPSJ Tohoku Branch for his oral presentation about the simple self-diagnosis system of asymptomatic cerebral infarction

Main Works:
• His research interests include human-centered computing and software engineering.

Membership in Academic Societies:
• Information Processing Society of Japan (IPSJ)

Name:
Kazutaka Mitobe

Affiliation:
Graduate School of Engineering Science, Akita University

Address:
1-1 Tegata-gakuen-machi, Akita 010-8502, Japan

Brief Biographical History:
1991 Received the B.E. degree in electrical engineering from Akita University
1996 Received the Ph.D. (Eng.) degree from Hokkaido University
1996- Joined Akita University
2013- Professor, Akita University

Main Works:
• His research interests include biomedical engineering such as human motion analysis and psychophysical experiments in adults.

Membership in Academic Societies:
• The Institute of Electrical and Electronics Engineers (IEEE)
• The Institute of Electronics, Information and Communication Engineers (IEICE)
• Human Interface Society
• Japanese Council of Traffic Science