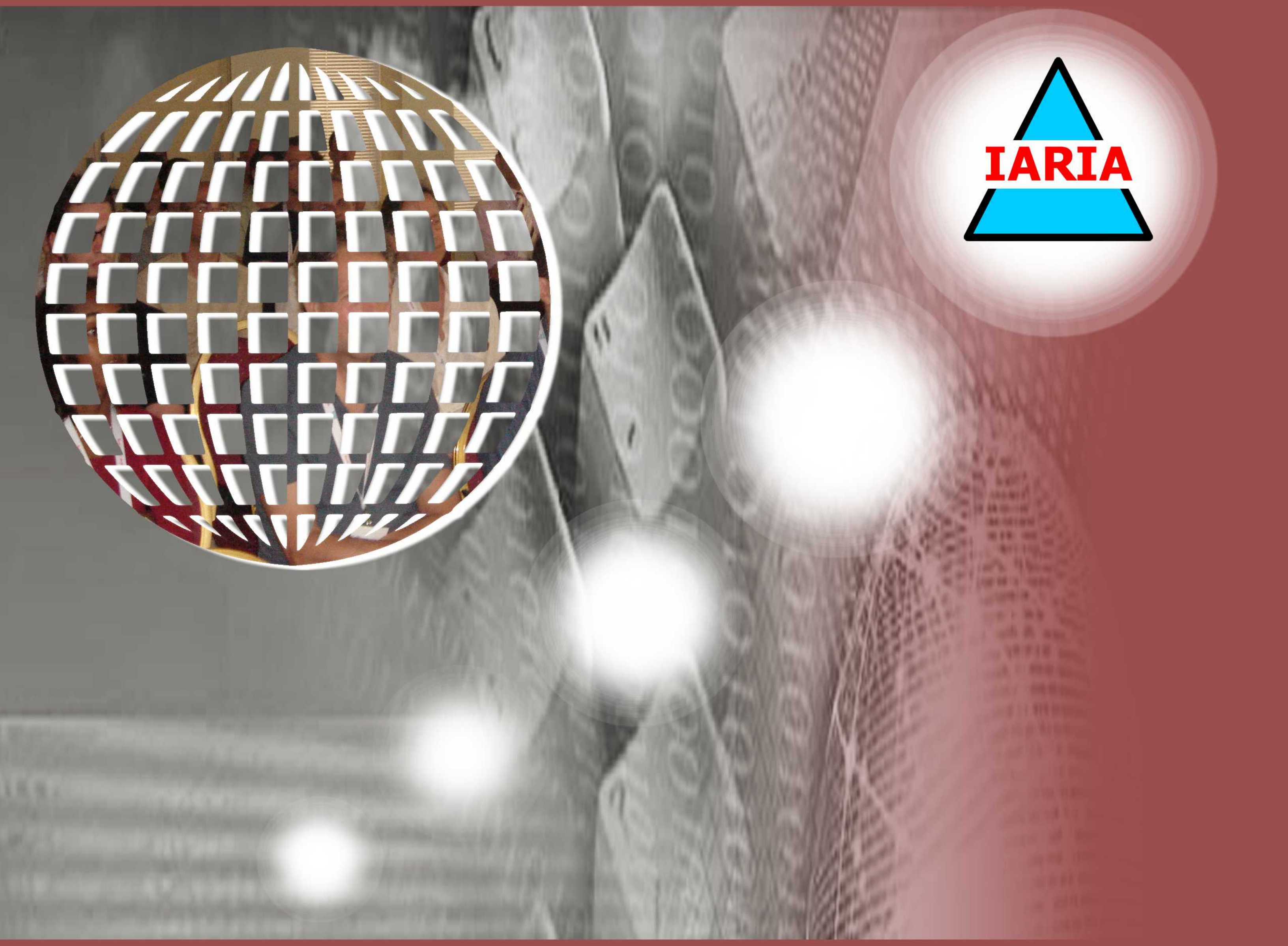
International Journal on Advances in Telecommunications



2019 vol. 12 nr. 3&4

The *International Journal on Advances in Telecommunications* is published by IARIA.
ISSN: 1942-2601
journals site: http://www.iariajournals.org
contact: petre@iaria.org

Reference should mention:

International Journal on Advances in Telecommunications, issn 1942-2601
vol. 12, no. 3 & 4, year 2019, http://www.iariajournals.org/telecommunications/

Reference to an article in the journal is as follows:

<Author list>, "<Article title>"
International Journal on Advances in Telecommunications, issn 1942-2601
vol. 12, no. 3 & 4, year 2019, <start page>:<end page> , http://www.iariajournals.org/telecommunications/

Sponsored by IARIA
www.iaria.org

International Journal on Advances in Telecommunications
Volume 12, Number 3 & 4, 2019

Tudor Palade, Technical University of Cluj-Napoca, Romania
Constantin Paleologu, University Politehnica of Bucharest, Romania
Stelios Papaharalabos, National Observatory of Athens, Greece
Gerard Parr, University of Ulster Coleraine, UK
Ling Pei, Finnish Geodetic Institute, Finland
Jun Peng, University of Texas - Pan American, USA
Cathryn Peoples, University of Ulster, UK
Dionysia Petraki, National Technical University of Athens, Greece
Dennis Pfisterer, University of Luebeck, Germany
Timothy Pham, Jet Propulsion Laboratory, California Institute of Technology, USA
Roger Pierre Fabris Hoefel, Federal University of Rio Grande do Sul (UFRGS), Brazil
Przemyslaw Pochec, University of New Brunswick, Canada
Anastasios Politis, Technological & Educational Institute of Serres, Greece
Adrian Popescu, Blekinge Institute of Technology, Sweden
Neeli R. Prasad, Aalborg University, Denmark
Dušan Radović, TES Electronic Solutions, Stuttgart, Germany
Victor Ramos, UAM Iztapalapa, Mexico
Gianluca Reali, Università degli Studi di Perugia, Italy
Eric Renault, Telecom SudParis, France
Leon Reznik, Rochester Institute of Technology, USA
Joel Rodrigues, Instituto de Telecomunicações / University of Beira Interior, Portugal
David Sánchez Rodríguez, University of Las Palmas de Gran Canaria (ULPGC), Spain
Panagiotis Sarigiannidis, University of Western Macedonia, Greece
Michael Sauer, Corning Incorporated, USA
Marialisa Scatà, University of Catania, Italy
Zary Segall, Chair Professor, Royal Institute of Technology, Sweden
Sergei Semenov, Broadcom, Finland
Dimitrios Serpanos, University of Patras and ISI/RC Athena, Greece
Adão Silva, University of Aveiro / Institute of Telecommunications, Portugal
Pushpendra Bahadur Singh, MindTree Ltd, India
Mariusz Skrocki, Orange Labs Poland / Telekomunikacja Polska S.A., Poland
Leonel Sousa, INESC-ID/IST, TU-Lisbon, Portugal
Cristian Stanciu, University Politehnica of Bucharest, Romania
Liana Stanescu, University of Craiova, Romania
Cosmin Stoica Spahiu, University of Craiova, Romania
Young-Joo Suh, POSTECH (Pohang University of Science and Technology), Korea
Hailong Sun, Beihang University, China
Jani Suomalainen, VTT Technical Research Centre of Finland, Finland
Fatma Tansu, Eastern Mediterranean University, Cyprus
Ioan Toma, STI Innsbruck/University Innsbruck, Austria
Božo Tomas, HT Mostar, Bosnia and Herzegovina
Piotr Tyczka, ITTI Sp. z o.o., Poland
John Vardakas, University of Patras, Greece
Andreas Veglis, Aristotle University of Thessaloniki, Greece
Luís Veiga, Instituto Superior Técnico / INESC-ID Lisboa, Portugal
Calin Vladeanu, "Politehnica" University of Bucharest, Romania
Benno Volk, ETH Zurich, Switzerland
Krzysztof Walczak, Poznan University of Economics, Poland
Krzysztof Walkowiak, Wroclaw University of Technology, Poland
Yang Wang, Georgia State University, USA
Yean-Fu Wen, National Taipei University, Taiwan, R.O.C.
Bernd E. Wolfinger, University of Hamburg, Germany
Riaan Wolhuter, Universiteit Stellenbosch University, South Africa

International Journal on Advances in Telecommunications
Volume 12, Numbers 3 & 4, 2019

CONTENTS

Attempts of Fading Student Support in E-learning

Testing a hypothetical model of minimum support through a pilot study

Takeshi Matsuda
University Education Center
Tokyo Metropolitan University
Hachioji City, Tokyo, Japan
e-mail: mat@tmu.ac.jp

Mitsuru Kimoto & Ken Kuriyama
Gakken Juku Holdings
Gakken Research Institute for Learning and Education
Shinagawa Ward, Tokyo, Japan
e-mail: m.kimoto@gakken.co.jp K.Kuriyama@gakken.co.jp

***Abstract*—Mentoring support for students who use self-regulated, home-based e-learning often leads to the students becoming too dependent on that support. This paper describes a pilot study that examined the minimum level of mentoring that junior high school students needed to keep to a home-based e-learning program, with a view to informing a "fading" strategy that will leave students not needing any support. The study was done over two months and involved four e-mentors and 14 students at a "Juku" (private preparatory school) in Japan. Data gathered from the e-learning system's log as well as the results of questionnaires and interviews were used to specify the minimum support model. Three major patterns or types of learning were identified. The study concluded that the pattern where students are reminded by mentors to start their learning sessions but are thereafter left to their own devices indicates the minimum level of support needed.**

Keywords-Online learner support; e-learning; self-regulated learning; fading; minimum supprt model.

I. INTRODUCTION

This paper is an extension of our previous presentation [1] at an IARIA conference.

Juku in contemporary Japan means a private preparatory school for university or high school entrance examinations. According to the Japanese government's statistics, there are 47,570 Juku schools all over the country that employ more than 330,000 people [2]. Gakken Juku Holdings is one of the largest managing companies of Juku in Japan. As of November 2018, it operates 16,452 Juku schools. The company was planning to introduce flipped classroom style courses nationwide in its financial year 2019 and started to cultivate human resources capable of supporting learners online.

Following the flipped classroom approach, in the initial plan students were required to study at home first, using drill materials for basic tasks and video materials explaining the tasks, and then to come to the classroom to ask questions about things that are unclear to them, as well as to complete applied tasks.

The tasks and videos that students use at home were developed and provided as student-centered adaptive learning content, using artificial intelligence, and proved to be effective. However, students have to learn how to learn, because with the flipped classroom approach it is the students, not the teachers, who need to control learning, in particular "anytime-anywhere" style e-learning or asynchronous distributed e-learning. How to achieve this was not addressed at the time. Self-regulated learning (SRL) is one of the theoretical solutions.

II. RELATED WORK AND PURPOSE OF RESEARCH

The acquisition of SRL skills, which means learning how to learn, is often said to be an important competence in the twenty-first century [3]. For example, it's one of the eight key competences enumerated in the 'Recommendation on Key Competences for Lifelong Learning', which was adopted by the European Parliament and the Council in December 2006 [4]. In Japan, the latest national curriculum also emphasizes the necessity of shaping students' learning habits and autonomy in secondary education [5].

SRL theories attempt to model how each of these cognitive, motivational, and contextual factors influence the learning. According to a social cognitive perspective, SRL is divided into three cyclical phases: forethought, performance, and self-reflection (Fig. 1) [6][7][8]. In this study, we

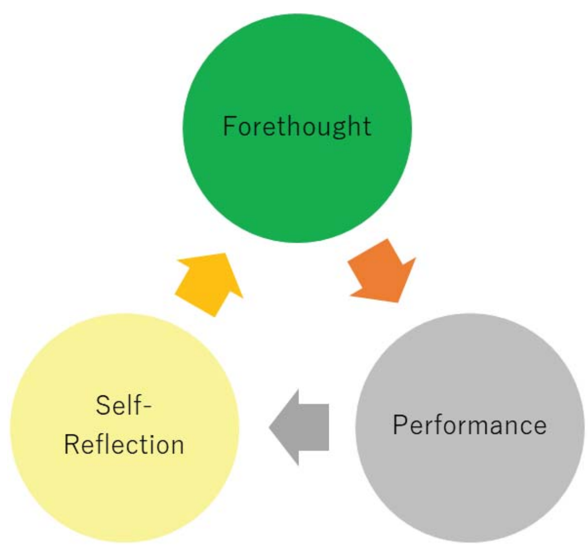


Figure 1. Phases of self-regulated learning.

investigated ways to support the performance phase; that is, learning itself.

Continuous e-learning needs self-regulation. However, it is difficult for most learners to acquire SRL skills by themselves. In other words, ordinary students do not become good self-regulated learners automatically. Therefore, the challenge that we have to overcome is how to support them to be self-regulating. Research that supports SRL using asynchronous distributed e-learning has been carried out and reported on from several perspectives in Japan. Examples are the introduction of elements of gamification [9], a system that automatically detects and warns of learning delays [10], a system that does not allow students to get access to content without having registered their own schedule [11], and human online supporters or professional "e-mentors" [12].

Among them, support by e-mentors does not require special software nor a change in learning content. Support can be offered through ad hoc communication by real people with high availability. Furthermore, there are advantages such as that it is easy to introduce and effective in various types of learning programs.

However, to provide effective support as an e-mentor, besides understanding the teaching content and system, skills are needed to effectively and efficiently implement online communication and adequate intervention with regards to learners' SRL. In addition, when providing a high level of quality support to all learners, the number of learners that can be handled by one e-mentor is limited. Also, some learners do not improve their SRL skills and start to rely totally on e-mentors. These disadvantages cannot be ignored in the education service industry, which requires verification of the effect of e-mentors from an economic as well as the educational point of view. The aim is to promote the autonomy of the learner while ensuring the learning support effect and being cost-effective.

There are several names for the professionals motivating and supporting students online, e.g., tutor, adviser, and coach. We us the word "mentor" because for junior high school students, instructors in private tutoring schools, especially part-time university students, are counseling partners who are close to their age, and their personality engenders trust in the learners.

In addition to learning effects, there is a movement to introduce learning support activities from the viewpoint of quality assurance of education and accountability. In quality assurance of asynchronous distributed e-learning, learning support is one of the important elements. Especially when supporting junior high and high school students who are not ready for SRL, the focus is likely to be on "coaching" and "scaffolding". This means that the aim of guiding a student to be an autonomous learner or an SRL expert is lacking in many studies.

Hence, in this research, we focused on "fading", an approach that is often overlooked. Fading means that a mentor gives a student only the minimum support they need, with a view to gradually decreasing that support until the student can practice SRL successfully on their own.

In previous research reports and papers, several methods of fading have been proposed. The early practice of the fading graduated reduction model contains detailed support and then involves lessened support over time [13][14]. In recent cases, however, most fading approaches relate to fading support all at once at the end of the program [15]. Therefore, even when fading is implemented, as soon as support is faded, students are immediately required to jump in and exert self-regulation of their performance, which they had no opportunity to practice before. This indicates that whereas fading may be necessary to provide the opportunity to practice the performance of a strategy and thereby acquire strategy knowledge, it may not be sufficient [16].

On the other hand, an advanced model for fading offers graduated reduction of skills to enhance students' autonomous activity in attaining the desired skills [17]. After all, effective fading methods are being studied, and there is no unquestionable theories that can be generalized [18][19].

Taking this situation into account, we decided to investigate the tentative goal, or minimum support level before exploring its method. The aim of this study was to specify the minimum support level a student needs by analyzing log data from Gakken's learning management system (LMS), the results of a questionnaire filled out by learners and their supporters, as well as interviews with learners and supporters. The results would support Gakken in creating a realistic fading strategy so that students do not become overly dependent on their mentors and can progress towards practicing SRL on their own.

The rest of this paper is organized as follows. In Section II, the methods used in this study are described. This is followed by a presentation of the results in Section III, after which the conclusion and suggestions for future works are presented in Section IV. The acknowledgment closes the article.

III. METHODS

In this section, we describe our hypothetical model, the pilot program we used to test it, as well as the data we gathered during the process.

A. *Hypothetical Model*

A total of 14 junior high school students who attend a tutoring class at "Juku A", in Kobe city, in western Japan, were selected for the study. One of the selection criteria was that the students must be able to study online at home. E-mentors for the study were selected from among teachers at the same school. Juku A is managed by a subsidiary of Gakken. The e-learning program is composed of drill contents that cover five subjects (English, Japanese, Mathematics, Science, and Social Studies) and their explanation videos. Students and e-mentors collaborated to create a learning plan on the LMS according to the standard curriculum of the school before this pilot program was due to start and the students and e-mentors agreed times at which each learning session had to start. The learning plan for each subject was generally set at 60 minutes of home study once or twice a week. After undergoing a training program that was developed assuming full-scale implementation, e-mentors were assigned support activities based on activity guidelines. The study's hypothesis was that the minimum level of support that a student would need is to be notified at the scheduled start and end time of each day's e-learning session (see Fig. 2). This approach was incorporated into the guidelines for e-mentors.

B. *Pilot Program*

When it comes to applying SRL theory to practice, appropriate scalability or granularity of the time range matters. The granularity can range from a period of one day up to a year. In this study, we decided on an e-learning program and its learning support activities from October to December 2016 as a pilot program. Most junior high schools in Japan have a three-semester or trimester system that starts at the beginning of April. A school usually conducts school-wide tests twice per semester as mid-term and term-end tests, except for the last semester. We implemented this program from the end of the mid-term test in the second semester to the end of that semester, assuming an SRL cycle tailored to the term-end test (Fig. 3).

The students who participated in this program were junior high school students in the 7th and 8th grades, and all were doing extra-curricular club activities. Fig. 4 indicates their typical daily schedule. As is apparent, their days were quite busy and they would benefit from studying at home, using Juku content.

Four university students who were teachers at Juku A were selected as e-mentors and received approximately 25 hours of training in September 2016. The training was designed with reference to the e-Learning Professional tutor qualification skill set [7] and its training program. For the actual e-learning activity, Juku A created guidelines and defined activities and reporting methods (Table Ⅰ).

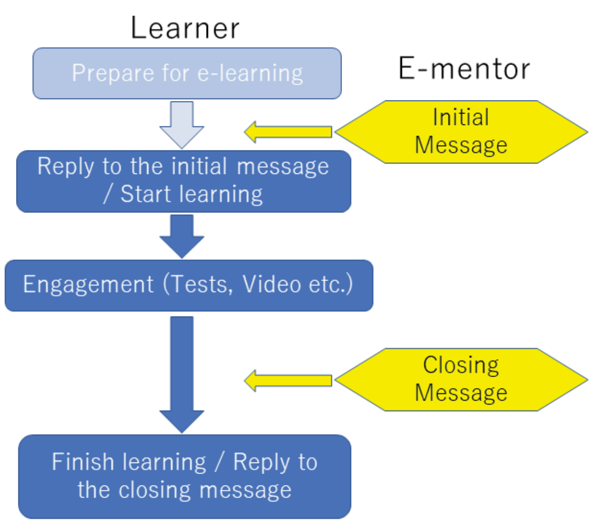


Figure 2. Hypothetical learning flow.

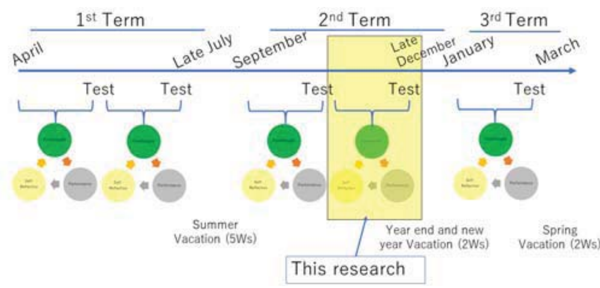


Figure 3. Period of this research.

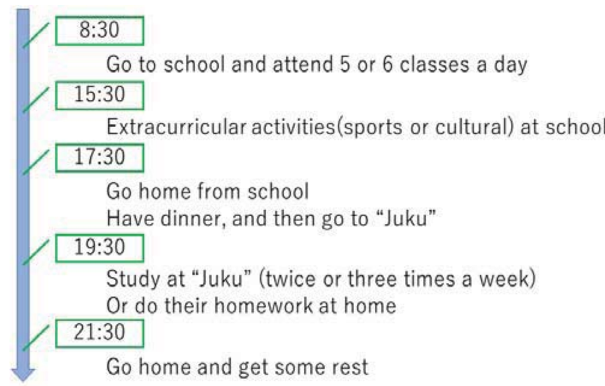


Figure 4. Typical day of participants.

TABLE I. PILOT PROGRAM OUTLINE

Item	Details
Period	Eight weeks (17 Oct.-19 Dec. 2016)
Learners	Junior high school students at Juku A, Kobe city (Fourteen volunteer students in total; Four seventh grade, Ten eighth grade)
E-mentors	Selected from one-on-one class teachers Passed a training course (Four university students)
System	Original learning management system
Contents	Drills and videos of five subjects

According to the guidelines, e-mentors were supposed to send messages at the beginning and end of each scheduled learning session. The message from the e-mentor was displayed on the dashboard that the learner saw immediately after logging in to the LMS, and he or she could respond with a smiley face emoticon that expressed a positive response or a crying emoticon that expressed a negative response (Fig. 5). Students could choose an option not to respond at all, either.

E-mentors were to check the login status of students at the start time of their scheduled learning session, and if a student had not logged in after 10 minutes from the scheduled start time, the e-mentor had to phone them to encourage them to start learning. In addition, while the learner was learning, the e-mentor was instructed to watch the work in real time and to "understand the learner's situation with LMS and give advice with the message function". These activities by the e-mentors were announced to learners in advance.

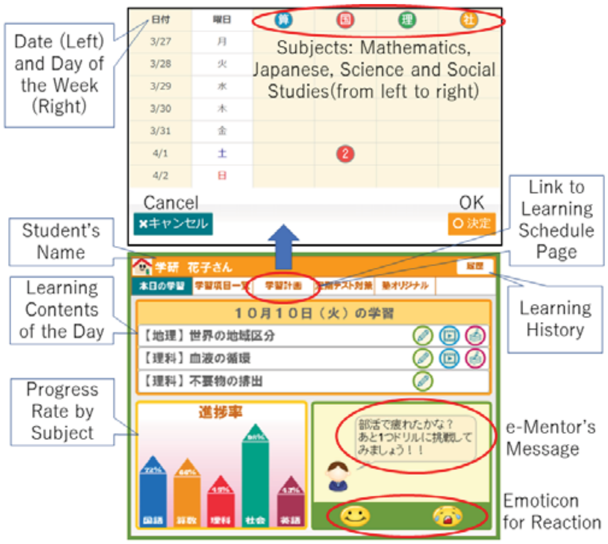


Figure 5. Screenshots of the learning management system (Top: Schedule, Bottom: Learner's dashboard).

The weekly schedule was displayed in the LMS, and students and e-mentors both had access to that screen (Fig. 5). Since it was important to know how to use the LMS via the terminal that the learner used, the e-mentor instructed the learner for around 30 minutes on the phone how to do this at the beginning of the first session.

Because e-mentors worked in shifts, they were instructed to create a daily activity record for each learner they were responsible for and to share this information with colleagues. E-mentors were told not to give any subject-specific instruction to students.

One reason for this is that the e-mentors were also tutors at Juku A, so teaching could be done face-to-face, which is more efficient. Furthermore, as a more fundamental reason for this, Juku A's intention is to create learning habits by using the content developed for SRL, rather than allowing students to simply ask questions when they get stuck with a subject.

C. *Collected Data*

Several kinds of data were available for this study, as is shown in Table II. The table indicates two types of data; quantitative and qualitative. The former includes LMS access logs, students' school test scores, and the answers to multiple-choice questionnaires. The latter consists of the contents of e-mentors' messages, free-text answers to the questionnaire, and the record of interviews with the e-mentors. The access log data were mainly used for developing the supporting models in this study and we analyzed the results of the questionnaires for students and e-mentors as auxiliary data (see Appendix A and B for all items of questionnaires). In addition, the learning environment of the learner and their school life are considered to have a large impact on actual learning activity,

TABLE II. AVAILABLE DATA

Source	Category		
	Profile	***Questionnaire***	***Access Log***
Students	Name of school Grade Schedule of tests	Pre and Post	Access logs of LMS Responses to e-mentor messages Online test scores
E-mentors	Work experience Name of University Major	Pre and Post	Access logs of LMS Messages Records of training program Work records
Manager of Juku A	-	-	Design Specification of LMS Guidelines

so we collected data such as the term-end test schedule of the learner through interviews in order to consider the influence of extra-curricular club activities and the schedule of school events.

In this study, we did not evaluate the e-learning content or teaching methods and considered the change in learners' test scores as an indirect effect. The reason is that the pilot program that was the subject of this study was a rehearsal, with limited participants and duration. Another reason was that we were trying to achieve SRL ability through learning support by e-mentors.

IV. RESULTS

First, we discuss the log data and messages that we analyzed, and then we present the study patterns that emerged, as well as an analysis of the perceptions of the students and their e-mentors.

A. *Summary of Logs*

Table III shows a summary of the students' logs on the LMS. In this paper, log means the number of days they got accessed to the sessions. It also shows the total number of scheduled learning days (128) for all the students combined. There were 96 learning days with messages from a mentor, 11 learning days without messages, and 21 no-learning days with messages (Fig. 6). Therefore, we analyzed 107 days, being the total number of learning days. Although it could provide valuable insights as to why the students did not learn as scheduled on those 21 days, there was nothing to analyze because data did not exist for these days.

As described above, the 14 participants learned over the course of eight weeks in this pilot program. The total number of logs for learners was 1,504, which account for 107.4 on average per person. The maximum number of logs was 242 and the minimum was 4 (Table III). The reason for the large range was that there were learners who dropped out after learning for one or two days, and that the learning frequencies were either once a week or twice a week.

TABLE III. LEARNERS' LOGS ON LEARNING MANAGEMENT SYSTEM

		Days	Logs	Messages from Mentor
Total Number (incl. no-learning days)		128	1504[a]	258
Average Number per Student		9.14	107.43	18.43
Range	Maximum Value	19	242	38
	Minimum Value	4	4	5

a. Including 106 logs on the days without any messages

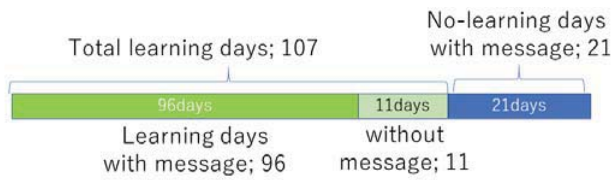


Figure 6. Breakdown of the total learning days.

TABLE IV. MESSAGE CONTENTS FOR EACH E-MENTOR

Message	e-Mentors					Total
	1	*2*	*3*	*4*	*5*[a]	
Prompt Start	13	32	16	21	1	83
Content of Study	14	29	17	13	2	75
Praise	2	5	4	4	0	15
Learning Pace	3	6	16	2	1	28
Closing Greeting	9	28	7	9	1	54
Other	0	2	1	0	0	3
Total	41	102	61	49	5	258

a. E-mentor 5 worked as a substitute for absentee

B. *Messsages*

The total number of messages sent by e-mentors throughout the pilot program was 258, being an average of 63.3 per e-mentor (with an average of four mentors, excluding one who worked temporarily as a substitute for an absentee). The average number of messages was 18.4 per learner, and 2.4 per study day per learner. As for the contents of the messages, ones that encouraged students to start learning were the most common, followed by instructions on the contents of the learning material, praising learners concerning pace of learning, and the greeting at the end of the learning session (Table Ⅳ).

Among these, instruction on the contents were not the same as subject instruction which the e-mentors were told not to provide. Most of them were showing which content should a student start to learn because he or she often forgot the last content they learned.

As mentioned earlier, in the guidelines, e-mentors were to send messages at the start and end of a scheduled learning session and were instructed to send an additional message if learning activities were stalling, so it can be said that the messaging activities were generally based on the guidelines.

Of the 14 learners, two did not use the emoticon response, and neither learnt much; one student had only four logs on the single day of logging in, and the other had a total of 27 logs and had two days of logging in. On an individual message basis, 92 of the e-mentors' messages received no response (35.7% of all messages). In the case of many ignored messages, there were responses to at least one other message received on the same day (47 messages), or on a day when the learner did not log in (22). Therefore, learners read messages from e-mentors on most study days. One of the causes of this phenomenon being observed is the system specifications. The system was designed to be able to send messages to students who were not logged in.

C. *Observed Patterns*

In order to confirm the learner's activity history after receiving the message, we classified the learning log data as either before or after the day's initial message from the e-mentor. As shown in Table V, most logs were recorded after receiving the first message from the e-mentor. Furthermore, the log activity before receiving the message includes a response (reply using emoticons) to a message that could not be responded to at the previous login, so it can be inferred that the messages played a role in getting learners to start learning.

Three main types of learning flow pattern became clear when we classified the learning processes based on the e-mentor's message timing. Type 1, shown in Fig. 7, is the flow originally assumed by Juku A. In this type, messages were sent twice, and the learner starts learning online or responding with the first message. The process is completed when the learner picks up the cue from the closing message or completes the session by replying to it. This type accounted for 34 days out of a total of 107 days.

TABLE V. DISTRIBUTION OF LOG

	Before MSG	After MSG	No MSG
Number of Logs	47	1,351	106
Ratio[a]	3.4%	96.6%	-

a. Excludes the logs on the days with no message from e-mentor

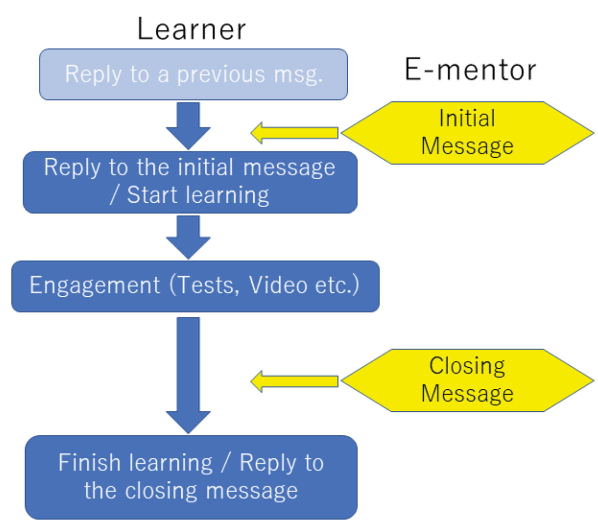


Figure 7. Type 1 learning flow pattern (34 / 107 days).

With Type 2, the learner begins to learn, motivated by the e-mentor's initial message, and ends after the same amount of time as in Type 1, but the learner receives a message from the e-mentor three times or more during the session (Fig. 8). This type is also within the scope of the guidelines and constitute 40 out of the 107 days.

Type 3 is a flow pattern in which the message is sent only once at the start and, the same as with Types 1 and 2, this initiates the online learning. As will be describes later, the e-mentors did not send a closing message because the student did not seem to end his or her study session (Fig. 9). Type 3 was less frequent than Type 1 or 2 and occurred on 12 out of the 107 days.

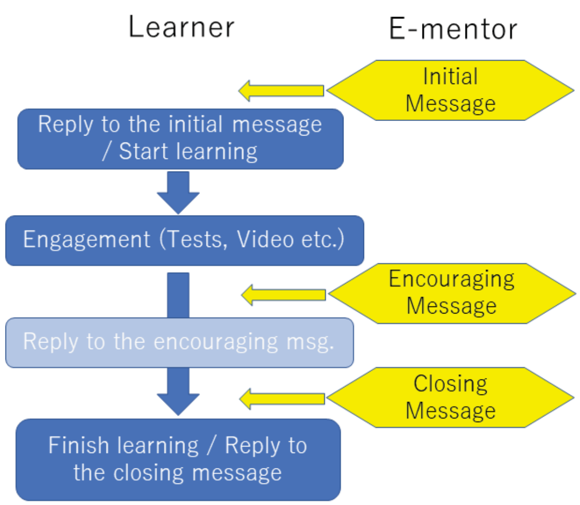


Figure 8. Type 2 learning flow pattern (40/ 107 days).

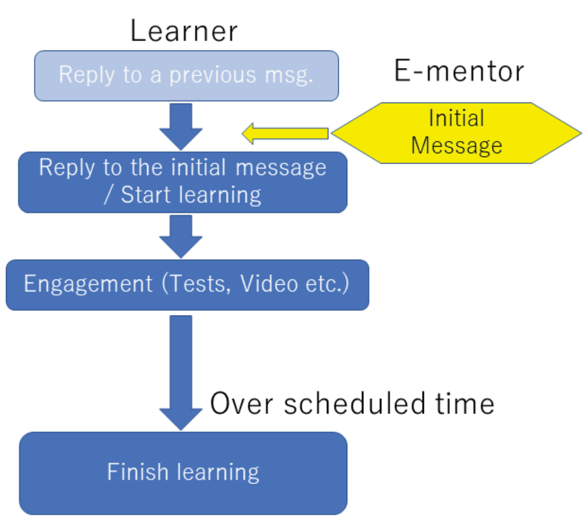


Figure 9. Type 3 learning flow pattern (12 / 107 days).

Some patterns were observed that were completely different from these three types. In the no-message type, the e-mentor did not send any message at all, however, learners accessed the course material voluntarily on 11 days. There were also 10 days of learning that did not follow any pattern and, as was explained previously, 21 instances of messages that did not results in any learning activity.

Eight learners had at least one day when they did not learn even when an e-mentor called, and five learners learned on a day that they were not scheduled to learn. There are eight students who accessed the LMS on a day when there was no call from an e-mentor. Of the three students except five who have studied on a day when they do not plan to learn, two used the LMS before the actual course started. One student learned only for one day and then dropped out. These five students seem to have had a planned strategy to make up for delays in learning or to modify the schedule according to their own circumstances.

Table VI shows the distribution of each type in line with a time series. Two situations are apparent.

First, learning continued after the end-of-term test. Learners were junior high school students who belonged to extra-curricular clubs. The course started about 10 days after the completion of the mid-term test. The term-end tests at the learners' various schools started from November 21 to December 8, and finished on November 24th to December 12th, before the winter vacation. It was assumed that the learners would start learning with the end-of-term test in mind. However, 11 students continued to study at the same pace after the end of the end-of-term test. As mentioned earlier, there were two learners who canceled the class at an early stage, so only one student stopped taking the class right after the term-end test.

According to Table VI, the number of days that students learned after December 11 did not drop significantly, and the ratio of Types 1 to 3 did not change. It is suggested that such learners got into the habit of doing e-learning in response to the messages from the e-mentors.

Second, Types 1 to 3 observed depending on the learner's situation. This means that individual students followed one of these patterns, depending on their situation on any given day. Moreover, Types 2 and 1 were the most common. The fact that there were many Types 1 and 2 indicates that e-mentors acted in line with their guidelines. On the other hand,

TABLE VI. TIME SERIES DISTRIBUTION OF LEARNING TYPE

Day /Month	**Observed Types of Learning Flow**					**Total**
	1	*2*	*3*	*Other*	*No MSG*	
October (at most 15 days)	13	10	4	3	4	34
1-10/Nov.	3	8	0	2	1	14
11-20/Nov.	4	6	1	1	1	13
21-30/Nov.	3	3	2	2	1	11
1-10/Dec.	6	6	3	1	3	19
11-19/Dec.	5	7	2	1	1	16
Total	34	40	12	10	11	107

there were Type 3 learning flow patterns where the closing message was not sent, and other types were also observed. Their causes are discussed in the next subsection.

D. Awareness of Students

The effect of the e-mentors' monitoring was confirmed by the questionnaire results for the learners. With the post-program questionnaire, we asked, "I felt I was being watched over by mentors" (Item number 6) and "" (Item number 22). Three out of 13 students (23%) responded negatively to both items 6 and 22, and this means that more than three-quarters of learners realized the effect of monitoring.

Looking more closely at the responses of the ten students who had positively evaluated this effect, seven answered positively to the item "e-mentor's presence helped establish a habitual learning custom at home" and so did eight respondents to the item, "the message from the mentor is encouraging". Nine students chose either "increase the type of reaction to mentors", "make it possible to send a text message to mentors", or "can make a video call with mentors" as a necessary improvement plan for learners (Table VII).

To summarize the findings from the results so far, it can be inferred that the message from the e-mentor played in role in getting students to start their sessions, judging by the reaction to the message and the timing of the learning activity. Therefore, the support effect was shown to some extent. In addition, many learners felt the effect of the e-mentors monitoring them and wanted more opportunities for discussions with e-mentors.

E. Perspectives of e-mentors

Regarding the e-mentors' perspectives, we examined the post-project questionnaire that e-mentors answered and their daily activity records. In the questionnaire, among the items that evaluate their own activities, all the e-mentors gave themselves the highest possible score for "explained the operation of the system by telephone at the beginning". System operation ignorance is a typical example of initial problems that are difficult to support in text-based communication. It was clear that they felt it was necessary to prevent this. Also, regarding the number of messages, both "too many" and "too few" got low responses and the frequency was deemed appropriate.

TABLE VII. ANSWERS TO QUESTIONNAIRE BY STUDENTS WHO EVALUATED MONITORING BY E-MENTOR POSITIVELY (*N=10*)

Positive Answer (Number)	**Communication** (%)	**Encouraging** (%)	**Learning Habit** (%)
Only item 6 (4)	4 (100)	4 (100)	2 (50)
Only item 22 (1)	1 (100)	1 (100)	1 (100)
Both item 6 and 22 (5)	4 (80)	3 (60)	4 (80)
(For reference) Negative answer (3)	2 (67)	1 (33)	2 (67)

On the contrary, on the following items all e-mentors felt anxiety and dissatisfaction:

- "Sometimes I was worried that the students would not read my message."
- "Sometimes the meaning of the reaction from students was not understood."

To solve these problems, it is necessary not only to improve e-mentor's skills, but also to develop information sharing functions or communication functions for the LMS.

In addition, we asked how many students could be assigned to an e-mentor based on this system; they answered that they could support a range of 10 to 30 students. This number was higher than the value (8-10 students) that Juku A expected, so it can be said that the support service can be further enhanced.

Next, in order to further examine these questionnaire results, individual semi-structured interviews were conducted by the first author with all four e-mentors. As a result, all of them shared the following impressions regarding work and management:

- They had very little to do during the e-mentoring because the work mainly involves watching the students' progress.
- If the job is the same as during the study, it is possible to handle more than ten students at a time by slightly staggering the start times of students.
- "I felt that the cooperation of parents was necessary for students to be able to regulate themselves."
- "Even though I worked as an e-mentor, there was no major change in traditional face-to-face instruction."

On the negative side, the opinions and explanations of each e-mentor were as follows:

- "When I did not want the student to finish studying at the scheduled end of the session, I sometimes did not send a closing message."
- "I wanted to teach rather than monitor, so it was a job that wasn't very good for me."

From these statements, the reason for Type 3 in the previous subsection becomes clear. There was a concern that the guidelines were not met.

A lesson learned from these results is that useful information can be gleaned even from results that are generated when guidelines are not followed, e.g., from the Type 3 learning flow pattern.

V. CONCLUSION AND FUTURE WORK

In this section, we discuss the limitations of the study before we come to the discussion of our conclusion and the recommendations for future work to be done.

A. Limitations

Although this study was an on-site trial that created a situation as close as possible to the actual environment, it had several limitations, and data was collected under the following constraints:

- Data was collected in a small-scale program (14 learners participated) and a program conducted for a limited period (about two months).
- Participants in the pilot program were recruited, and only those who had a network line at home and a terminal that could be used for learning were selected. In other words, it was a program aimed only at those who were highly motivated and well equipped.
- An e-learning schedule was established that fully reflected the learner's wishes. That is, there was no direct support for the planning phase of SRL, and the learner him- or herself alone decided the e-learning schedule.

The impact of these constraints on the extraction of learning patterns can be described as follows. First, because the number of learners was small, it was impossible to examine data using a strict statistical hypothesis test, and it was not possible to form a learner model based on causal relationships. Furthermore, it was not possible to confirm long-term effects, especially the establishment of attendance habits.

B. Discussion

We observed three major patterns or types of learning flow through the pilot program. Two of them (Type 1 and 2) followed the expected processes and the rest (Type 3 and others) showed unexpected flows. According to the post-questionnaire, ten out of 13 students felt the effects of being monitored by e-mentors although their activities were quite limited. Type 3 should be the prototype of minimum support model because this shows some proficiency with SRL; starting on time using a message as a starting cue, features of self-control, and concentration on their work. Type 3 also shows the possibilities that may lead to the establishment of students' learning habits, which is one of the major characteristics as an expert self-regulated learner [20].

It is possible to increase the number of learners per e-mentor to at least ten for Type 3, judging from the comments of e-mentors. In addition, the treatment of learners who continue learning even when they reach the originally scheduled end of the session should be added to the guidelines. In order to establish learning habits at home, it is considered effective to add an information supplement and to request the parents to cooperate.

Lastly, when e-mentor candidates are selected, those who are convinced that an e-mentor has a different role from an instructor should be chosen.

C. Future Work

These are the points that should be improved upon and the issues to be addressed in order to devise methods for starting full-scale e-learning and a learner support service:

1) Development of management methods and systems that enable e-mentors to work effectively and efficiently

Specifically, how to arrange e-mentors' work shifts, how to improve the existing guidelines for e-mentors, what information should be offered to e-mentors, and what interface of the LMS should be presented will be considered. We plan to apply learning analytics knowledge that uses learner's own information and data recorded in the LMS in order to address these issues.

2) Support in the SRL phases other than the performance phase

In this pilot program, support during the performance phase was carried out, and we will develop support methods for the planning phase and the reflection phase for the sake of providing appropriate interventions in SRL.

3) Methods of fading or removal of the scaffold

As mentioned at the beginning of this paper, Juku A aims to provide e-learning as an opportunity for students to acquire SRL ability and to encourage them to become self-regulated learners. This means that it is not desirable to continue learning support in the performance phase, and it should change to a situation where students continue to learn systematically without direct learning support, so that no students have to rely on e-mentors.

To achieve students' SRL, fading practices that reduce support and help students to acquire autonomy are important. In this pilot program, we did not reach the stage of fading, so how to do fading without difficulty, in particular how to lead students who act according to Type 2 to Type 3, is one of the major future challenges.

ACKNOWLEDGMENT

This work was supported by the research grant "Development of management method of learning service using video teaching contents for elementary, middle and high school students" from Gakken Juku Holdings (Fiscal Year 2017-2019). We also would like to thank Editage (www.editage.com) for English language editing.

REFERENCES

[1] T. Matsuda, M. Kimoto, and K. Kuriyama, "Development of Minimum Support Model in e-Learning", in The Eleventh International Conference on Mobile, Hybrid, and On-line Learning, Athene, Greece, 2019, unpublished.

[2] Ministry of Economy, Trade and Industry, *Survey Report on the Actual Situation of Specific Service Industry.* [Online] Available from: http://www.meti.go.jp/statistics/tyo/tokusabizi/result-2/h29/pdf/h29report27.pdf 2019.01.31 in Japanese

[3] T. Mooj, K. Steffens, and M. S. Andrade, "Self-regulated and Technology-enhanced Learning: a European perspective", European Educational Research Journal, vol. 13, no. 5, pp. 519-528, October 2014, doi: doi.org/10.2304/eerj.2014.13.5.519

[4] European Parliament, *Recommendation of the European Parliament and of the Council of 18 December 2006 on Key Competences for Lifelong Learning.* [Online] Available from: http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:394:0010:0018:en:PDF

[5] Ministry of Education, Culture, Sports, Science and Technology, *Curriculum Guideline for Junior High School*, [Online] Avilable from http://www.mext.go.jp/component/a_menu/education/micro_

detail/__icsFiles/afieldfile/2019/09/26/1413522_002.pdf in Japanese

[6] B. J. Zimmweman and D. H. Schunk, Handbook of Self-regulation of Learning and Performance. Routledge, New York, 2011.

[7] D. H. Schunk and B. J. Zimmerman, A Motivation and Self-Regulated Learning: Theory, Research, and Applications, Routledge, New York, 2007.

[8] P. R. Pntrich, "A conceptual framework for assessing motivation and self-regulated learning in college students" , Educational Psychology Review, vol. 16, pp. 385- 407, March 2004, ISSN: 1040-72626

[9] W. Sunayama, T. Atsumi, K. Nishimura, and K. Kawamoto, "Learning Support Environment by On-Line Competition QuizSystem", Journal of Japan Society for Fuzzy Theory and Intelligent Informatics, vol. 26, no. 2, pp.637-646, April 2014, doi: doi.org/10.3156/jsoft.26.637 in Japanese

[10] M. Ueno, "Data mining and text mining technologies for collaborative learning in an ILMS 'Ssamurai'", IEEE International Conference on Advanced Learning Technologies , IEEE, August 2004, pp. 1052-1053, doi: 10.1109/ICALT.2004.1357749

[11] M. Yamada, Y. Goda, T. Matsuda, Y. Saito, and H. Miyagawa, "Self-Regulator: Preliminary Research of the Effects of Supporting Time Management on Learning Behaviors" The 17th IEEE International Conference on Advanced Learning Technologies (ICALT 2017), IEEE Computer Society, July 2017, pp. 370-372, doi: doi.org/10.1109/ICALT.2017.85

[12] T. Matsuda, "Organizing e-Mentors: Development and Management", EdMedia 2008 -World Conference on Educational Multimedia, Hypermedia & Telecommunications, Association for the Advancement of Computing in Education (AACE), June 2008, pp. 5308-5313, ISBN 978-1-880094-65-5

[13] S. Bulu and S. Pederson, "Scaffolding middle school students' content knowledge and ill-structured problem solving in a problem-based hypermedia-learning environment" Educational Technology Research and Development, vol. 58, no. 5, pp. 507–529, October 2010, doi: doi.org/10.1007/s1142 3-010-9150-9

[14] K. L. McNeil, D. J. Lizotte, J. Krajcik, and R. W. Marx, "Supporting students' construction of scientific explanations by fading scaffolds in instructional materials", Journal of the Learning Sciences, vol. 15, no. 2, pp.153–191, November 2006, doi: doi.org/10.1207/s15327809jls1502_1

[15] S. Gidalevich, and B. Kramarski, "The value of fixed versus faded self-regulatory scaffolds on fourth graders' mathematical problem solving", Instructional Science, vol. 47, pp. 39–68, November 2018, doi: doi.org/10.1007/s11251-018-9475-z

[16] C. Wecker and F. Fisher, "From guided to self-regulated performance of domain-general skills: The role of peer monitoring during the fading of instructional scripts." Learning and Instruction, vol. 21, no. 6, pp. 746-756, December 2011, doi: doi.org/10.1016/j.learninstruc.2011.05.001

[17] S. Puntambekar and R. Hubscher, "Tools for scaffolding students in a complex learning environment: What have we gained and what have we missed?", Educational Psychologist, vol.40, no. 1, pp. 1–12, June 2005, doi: doi.org/10.1207/s15326985ep4001_1

[18] T. Jaakkola and K. Veermans, "Exploring the effects of concreteness fading across grades in elementary school science education", Instructional Science, vol. 46, no. 2, pp.185–207, April 2018, doi: doi.org/10.1007/s11251-017-9428-y

[19] A. A. Tawfik, V. Law, X. Ge, W. Xing, and K. Kim, "The effect of sustained versus faded scaffolding on students' argumentation in ill-structured problem solving", Computers in Human Behavior, vol. 87, pp.436-449, October 2018, doi: doi.org/10.1016/j.chb.2018.01.035

[20] T. Matsuda, Y. Saito, and M. Yamada, "Learners' Planning Habits Matter: The Variable That Affects Self-Regulation in e-Learning", E-Learn 2009 -World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, Association for the Advancement of Computing in Education (AACE), October. 2009, pp. 2917-2921, ISBN 978-1-880094-76-1

APPENDIX

A. Post-Course Questionnaire Items for Students (Likert Scale, 1: Not at all agree- 4. Totally agree, Excerpt)

Q1. Please circle the number that best describes your current thoughts and situation regarding the “smart drill” and e-mentor assistance you received this time. If you selected “Yes” in the last question (No. 25), select the function that could not be used.

1. I could learn by flowing my plan.
2. Messages from e-mentors encouraged me.
3. I tried to learn earlier than scheduled time.
4. There was a day I was never motivated for the soul of me.
5. I could immediately learn how to use Smart Drill.
6. I felt I was being watched over by mentors.
7. Explanation movies were able to be played without problems.
8. Smart drills are more suited to me than going to Juku.
9. I started learning from my favorite subject.
10. I started learning from my weak subject.
11. It took longer than I expected to study once.
12. It was good to know right and wrong answers immediately after I answered.
13. I sometimes ignored messages from mentors.
14. I was encouraged to see a chart showing the progress of my learning.
15. I was able to use Juku and smart drill separately.
16. It was interesting to study with a smart drill.
17. I sometimes felt sleepy with a smart drill.
18. With smart drills, I was able to study more intensively than at school.
19. I felt pressed when I got a call from a mentor.
20. I thought there might be more difficult learning content.
21. It was good that learning to solve the problem was the main program.
22. I felt I couldn't skip because there were mentors.
23. There should be a function to ask questions to mentors.
24. This program will help me get into the habit of studying in my home.
25. Some functions were not available on my home computer or tablet. (For this question alone, the choices were yes or no.)

If you answered ‘No’ in the previous question, select all the functions that you could not use and enclose them with a circle.

Options: 1. Drill, 2. Movie, 3. Test, 4. Learning Time, 5. My progress of Learning

B. Post-Course Questionnaire for e-Mentors (Likert Scale, 1: Not at all agree- 4. Totally agree, Excerpt)

Question 4. Please circle the number that best applies to the learning support you have provided and the system, Smart Drill, you have used.

1. I supported students without any problems.
2. I was sometimes worried whether students were reading my messages.
3. I understood the contents of the mentoring guidelines.
4. Information sharing notes, mentoring reports, were useful for business transfer.
5. I sent too many messages to students.
6. I sent too few messages to students.
7. I sometimes couldn't wait and watch and called a student.
8. It’s good for us to have explained the operation of the system by telephone at the beginning.
9. I sometimes didn't understand the meaning of reaction from students.
10. I sometimes wanted to write a longer message.
11. I knew exactly what the students were doing on the system.
12. There were many changes in the learning plans.
13. It would be useful if you could see the screens that the students were operating.
14. I want more detailed guidelines.
15. I had a direct consultation with a learning coach or chief mentor.

Question 5. Based on this experience, how many students do you think can support? Write the approximate number of people in increments of 10 people. (Example: I can support up to 50 students.)

Noise Level Detection Method for General Video

Chinatsu Mori and Seiichi Gohshi

Kogakuin University
1-24-2 Nishi-Shinjuku, Shinjuku-ku, Tokyo, Japan
Email: gohshi@cc.kogakuin.ac.jp

***Abstract*—Continuous efforts on TV technology have been carried out over the years with respect to resolution enhancement. Currently, 4K TV is a standard TV and 8K broadcasting is planned to begin in December 2018. High resolution in conjunction with low noise is an essential figure of merit in video systems. Unfortunately, any increase in resolution unavoidably increases noise levels. A signal processing method called "noise reduction" or "noise reducer (NR)" is often used to reduce noise. However, accurate noise level is needed when NR method is employed. Noise level depends mostly on lighting conditions and is estimated by comparing adjacent frame difference. However, the frame difference is generated by moving objects as well as noise. Therefore, it is essential to determine whether the frame difference is caused by the moving objects or by the noise, which is a difficult task. Another difficulty arises from the fact that noise level detection must be achievable in real-time conditions since all video systems are required to work in real-time. This means that a complex method could not be used for noise level detection. In this paper, two noise level detection algorithms are presented. The combination of two of them is a concise algorithm able to accurately detect the noise level and work in real-time conditions.**

Keywords–Video noise reducer; 4KTV; 8KTV; Real-time; Nonlinear signal processing; Image quality.

I. INTRODUCTION

A dramatic change in imaging technologies has taken place in the 21st century. High Definition Television (HDTV) broadcasting started only 20 years ago and at that time HDTV sets were expensive. Today, HDTV is already a part of history. 4K TV broadcasting started a couple of years ago and 8K satellite broadcasting is started in December 2018. Although significant advances have been made in video resolution, imaging technologies are based on the same principle, i.e., the photoelectric effect. Imaging devices primarily comprise of photoelectric cells and the number of electrons generated by each cell is proportional to the number of photons received by the cell. As the resolution increases from HDTV to 4K and then to 8K, the size of the image cell decreases, i.e., the number of photons per image cell is inversely proportional to the resolution. Therefore, it is necessary to amplify the electric energy of a video signal at the output of a video camera.

The electrical energy generated by the image cell is amplified by a pre-amplifier for each pixel. An amplifying process always results in thermal noise called "Gaussian noise." The level of noise is inversely proportional to the electric energy generated per cell. This is because fewer photons generate a lower voltage signal that requires amplification to achieve the appropriate voltage level. As HDTV, 4K, and 8K are high-resolution systems, the noise level increases because the size of the image cells becomes smaller due to the high-resolution. The best way to reduce noise in a high-resolution video is to increase the sensitivity of image cells' photoelectric effect. However, in order to achieve this, there are technical limitations, which need to overcome. Even high-end mature HDTV cameras may have pulse noise called "Shot noise" under poor lighting conditions, such as night time shooting or shooting in a dark room.

Noise reducer (NR) is a technology able to reduce noise in video systems by using signal processing techniques. Although, a large number of NR algorithms have been reported most of them are complex and only compatible with still images. The use of such an algorithm in real-time video systems would cause a video to freeze. In other words, complex NR algorithms are not suitable for use in real-time video systems. Another issue is the ability to detect accurate noise levels in video/image systems before applying noise reducing techniques. In case of real-time video systems, noise levels should be detected in real-time as well. Adjacent frame difference is a basic method to detect noise levels. However, noise, as well as moving objects, is contained in the frame, which makes the detection of accurate noise levels in a real-time video a difficult task. In this paper, a real-time noise level detection method is proposed [1].

This paper is organized as follows. In Section II, related works of NR and noise level detection are explained. In Section III, two noise level detection algorithms are proposed. In Section IV, simulation results are presented. In Section V, the advantages and disadvantages of the algorithms are discussed and the combination of two of them is investigated. Finally, in Section VI, conclusions of this work are presented.

II. RELATED WORKS

Conventional NR uses spatial or temporal digital filter to reduce noise [2]–[6]. Many NR methods are used for still images. They are spatial digital filters. Generally, the spatial digital filters cause image blurring. Although the common method is NR with wavelet transformation [7]–[10], the application of this method in videos is difficult: because real-time performance is required. Hence, an NR with a recursive temporal filter [11] is the only practical real-time method used for videos. Figure 1 shows the signal flow of the conventional NR method with the temporal recursive filter. The input is a noisy video frame, and the frame memory stores the previous output frame, where α $(0 < \alpha < 1)$ is the NR parameter. Higher values of the α indicate a higher NR effect. However, it is necessary to know the accurate noise level for the NR to work. Generally, videos comprise a wide variety of content with different noise levels. The differences are also caused

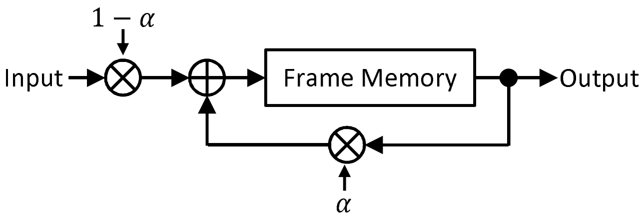


Figure 1. NR with recursive filter

by lighting conditions. In the development of automatic, real-time NR hardware, the NR parameter must be set properly in accordance with the actual noise level of a video. Although the adjacent frame difference is the basis of noise level detection, the frame difference is the result of noise and the moving areas.

Only a few proposals for noise level detection methods in videos are available. The wavelet transformation is used for the noise level detection [12], [13], but its real-time work application is difficult owing to its high processing cost.

The spatial and temporal digital filter is simple and is used for noise level estimation with low cost [14], [15]. Gaussian noise can be detected by applying high-pass filter, such as Sobel filter and Laplacian filter. However, these filters detect both noise and temporal moves of videos: the noise level is overestimated if the video includes fast and complex moves, such as camera works and object moves.

In the authors' previous works, a noise level detection method, which uses a bilateral filter has been proposed [16]. However, the bilateral filter also comes with a high hardware cost. A noise level detection algorithm is essential not only for the real-time function but also the accurate determination of the actual noise level. The method that uses the bilateral filter fails to perform when the noise level is high. Therefore, some improvements are necessary to address these issues.

III. Proposed Methods

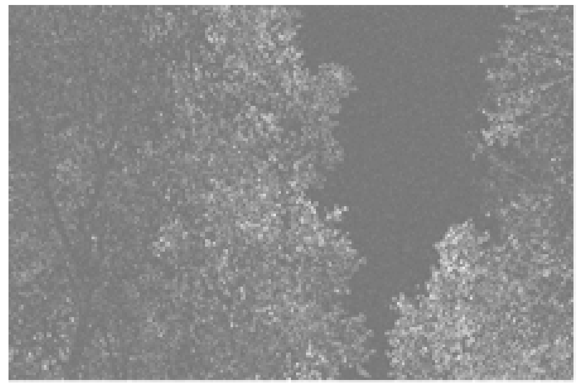
In this paper, two noise level detection algorithms for high and low noise levels area proposed, and the combination of these methods is considered.

A. Noise Level Estimation

A video has three axes, namely, vertical, horizontal, and the frame. The plane that consists of the vertical and horizontal axes is called spatial, whereas the frame axis is called temporal. By comparing the correlations of spatial and temporal, the spatial correlation is stronger than the temporal. The conventional NR [11] uses the temporal characteristic, as does the noise level detection algorithm. However, the adjacent frame difference is the most effective method to detect the noise level, but it involves two types of signals: frame differences caused by noise and that by moving objects in a video.

Figure 2 illustrates some examples. Figure 2 (a) presents the frame of a video [17]. In the sequence, trees and leaves rustle in the wind. Figure 2 (b) shows the frame difference caused by the trees and leaves. The noise level can be obtained by the standard deviation of the frame difference values in the flat areas because the frame difference in the flat areas is created by noise. Thus, separating the flat areas with frame difference caused by noise from the areas with moving objects

(a) Frame of a video sequence



(b) Frame difference of (a)

(c) appropriate areas of (b) for noise level detection

Figure 2. Video frame and frame difference

is necessary. The flat areas shown in Figure 2 (a) are marked with green in Figure 2 (c).

There are two characteristics of the frame differences for separating the flat areas and moving areas. The frame difference caused by moving objects has shapes and areas, whereas that caused by noise is isolated. Moreover, moving objects have large frame difference values, whereas noise often generates small difference values. Based on these characteristics, we introduce two NR methodologies.

B. Frame Difference and Threshold Process

As discussed in Section III-A, the frame difference values caused by the moving objects are larger, thus, distinguishing these two using a threshold process is possible. Figure 3 shows

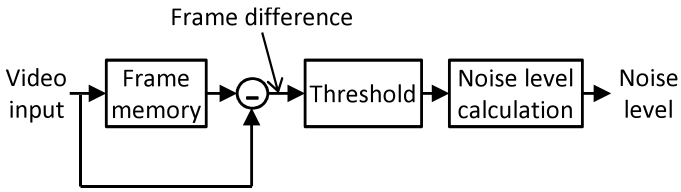


Figure 3. Frame difference and threshold process

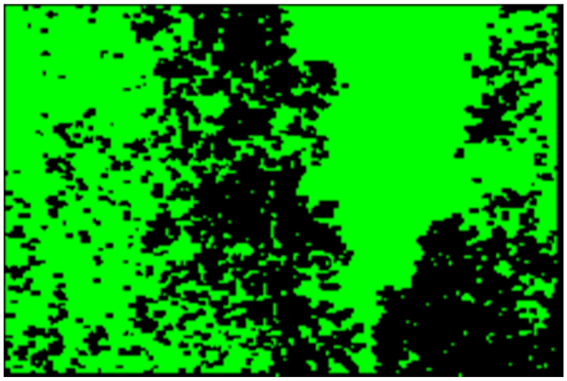


Figure 4. Areas detected using the frame difference and threshold process

the block diagram of the noise level detection with frame difference and threshold processing. The frame difference is detected using a frame memory and the input frame. In the threshold processing, only a small frame difference is selected, and its values and pixel numbers are sent to the noise level calculation block. In the noise level calculation block, the frame difference values and pixel numbers are accumulated. The average noise level can be measured using these two values. Figure 4 shows the candidate of the flat areas using the frame difference and threshold process. However, this method also incorrectly identifies the frame difference caused by moving objects in the tree areas. The moving objects do not always produce large frame difference values. With the luminance-level difference between the moving objects and the background, the frame difference values are small and can sometimes generate similar values to those caused by noise. Although the frame difference between the blue sky and the trees is substantial in the video shown in Figure 2 (b), the frame difference among the tree leaves is minimal and similar to the values caused by noise. The incorrect identification due to similar magnitudes in change between moving objects and noise is the problem with this method.

C. Proposed Method 1: Area Filter and Edge Detection

As shown in Figure 4, the frame difference caused by the tree leaves is detected as the flat areas for determination of the noise level. Although the moving objects, that is, trees and leaves, result in large frame difference values, some can be quite similar to the nearby areas, such as white shining leaves and the blue sky. The shining leaves and the sky produce small frame difference, such as noise because they have similar luminance levels. To prevent this issue, we need to connect these areas and exclude the spaces from analysis. Thus, we introduce the area filter and Canny edge detection [18] illustrated in Figure 5, to improve the noise level accuracy.

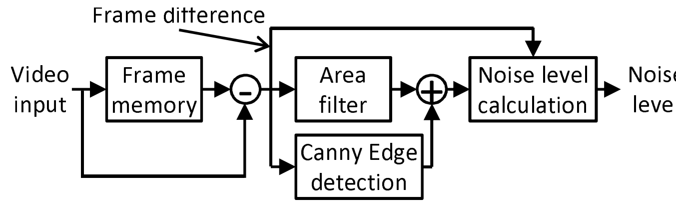
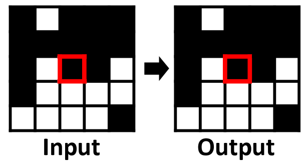
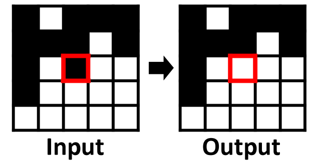


Figure 5. Proposed method 1



(a) Interest pixel as flat area



(b) Interest pixel as moving area

Figure 6. Examples of area filter process.

Based on the input to the frame difference detection, Figures 5 and 3 are similarly presented. The frame difference is distributed into three blocks: the area filter, the Canny edge detection, and the noise level detection in Figure 5. The function of the area filter is illustrated in Figure 6, and is a symmetric nonlinear type of filter. The center pixel value is processed with the surrounding pixel values and has two parameters, the kernel size and the threshold level. The kernel size is 5×5, as shown in Figure 6. The input of the area filter is the frame difference and has positive and negative values.

In the area filter block, the frame difference is processed with an absolute function to render all values positive. The absolute values are identified using the algorithm presented in Figure 6. The white pixels indicate values exceeding the threshold level, whereas the black pixels are equal to or less than the threshold level. If the number of the surrounding pixels exceeding the threshold level is the majority, the area filter decides the interest pixels as the moving area, otherwise, it decides the interest pixels as the flat area. As shown in Figure 6 (a), the number of pixels exceeding the threshold is 11 (the white bocks), and the number equal to or less than the threshold is 14 (the black blocks). In this case, the output of the center pixel is as the flat area. As shown in Figure 6 (b), the number of pixels exceeding the threshold is 14 (the black blocks) and less than or equal to the threshold is 11 (the white blocks). Therefore, the output of the center pixel is as the moving area. By using the following method, we can detect most of the moving areas in Figure 4, but not quite all of them. Therefore, we also introduce the Canny edge detection. The Canny edge detection identifies the continuous edges in the frame difference. These edges are caused by the leaves. A couple of pixels around the Canny detected edges are obtained from the Canny edge detection block. By using the logical OR on the area filter and edge detection blocks, the appropriate areas for the noise level detection are accurately detected.

D. Proposed Method 2: Isolated Point Removal and Motion Compensation

The proposed method 1 shown in Figure 5 can accurately detect the noise level when standard deviation is less than 9. We will discuss the problem in the following section in detail. To address the problem that arises when standard deviation is

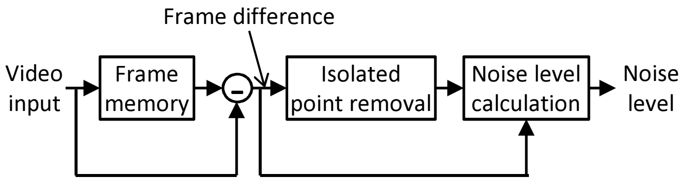
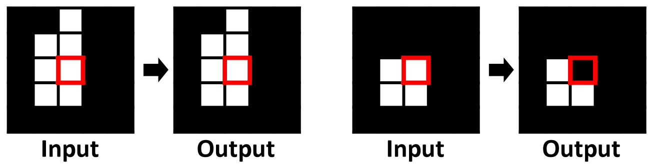


Figure 7. Proposed method 2-A



(a) Interest pixel in moving areas (b) Interest pixel in flat areas

Figure 8. Examples of isolated point removal process

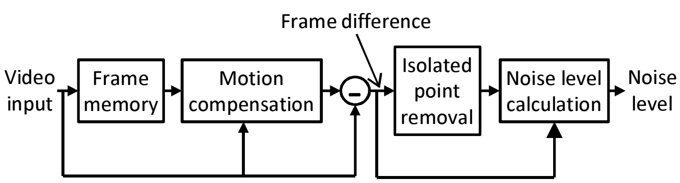
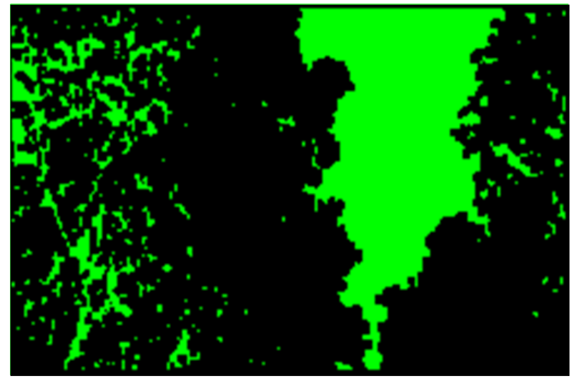


Figure 9. Proposed method 2-B

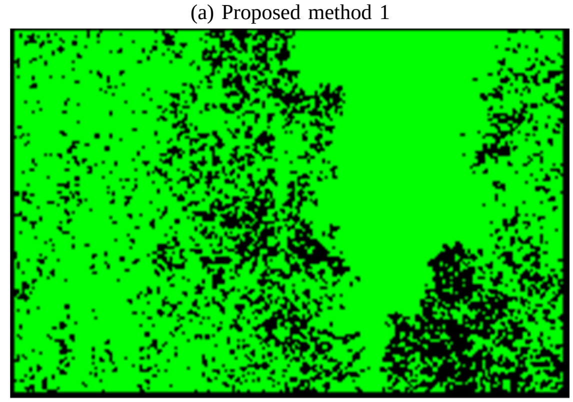
higher than 9, we have proposed another method.

The signal flow of the proposed method 2-A for a high-level noise is shown in Figure 7. The frame difference detection process of the input and frame memory blocks in Figure 7 is the same as that in Figure 5. The frame difference is distributed into two blocks. The first one is the isolated point removal block and the other one is the noise level calculation block. As discussed in Section III-A, the frame differences are caused both by moving objects and noise. Given that noise level can be detected in flat areas, discriminating the flat areas with noise from the entire frame is necessary. Generally, the frame differences caused by noise in flat areas are isolated. When isolated point removal is used, the output of the isolated point removal block can be the same as the frame difference caused by the moving object, and the noise level can be estimated using the areas excluding the detected moving areas.

The isolated point removal process is shown in Figure 8. The center pixel in Figure 8 is the interest pixel. Figure 8 (a) shows an example where the interest pixel is the moving area, and Figure 8 (b) illustrates the noise on the flat area. The input is the frame difference. Moreover, the absolute value of the frame difference is calculated and is binarized using the threshold level. The pixels shown in Figure 8 are the result of the binarization. The black areas are below or equal to the threshold level, indicating the flat area. Meanwhile, the white areas are higher than the threshold level, which are candidates similar to the moving areas or the noise on the flat areas. Using only the flat areas is necessary for the noise level estimation. Thus, in the isolated point removal process, the candidate pixels in the white areas are removed if the pixel is isolated and identified as the noise on the flat area. The parameter of the pixel size of the noise is used and the pixel size is set to 5 pixels, as shown in Figure 8. As presented in Figure 8 (a), the pixel size of the white area contains 7 pixels,



(a) Proposed method 1



(b) Proposed method 2-A

Figure 10. Areas for noise level estimation

which is larger than 5. The process identifies the area to be the moving area. As shown in Figure 8 (b), the pixel of the white area contains 4 pixels, which is less than 5. In this case, the pixel is determined to represent the noise, and it is removed.

Many frame differences are present in the frames. These differences have larger values when a video includes camera works, such as panning and tilting. However, the threshold process cannot detect the frame difference accurately for the noise level detection. Thus, we also introduce a block-based motion compensation to detect and reduce moving areas in the frame difference. The proposed method 2-A with motion compensation (method 2-B) is shown in Figure 9. The process of the motion compensation block; the frame is partitioned into blocks of pixels, and each pixel of a block is shifted to the position of the predicted block via the motion vector. This process is common in the discussions of video coding technologies, such as MPEG-2, MPEG-4, and HEVC. Furthermore, we verify and discuss the performance of the motion compensation in the following sections

The comparison of the areas for noise level estimation with the proposed methods 1 and 2-A is shown in Figure 10. The green areas show the flat areas that are used to calculate noise level, and the black areas show the estimated moving areas. Comparing the proposed method 1 and 2-A, they use different areas to calculate the nose level, thus, combining two methods it is able to estimate wide range of noise levels.

(a) Sequence 1 (b) Sequence 2 (c) Sequence 3

(d) Sequence 4 (e) Sequence 5

Figure 11. Test sequences

IV. Experiment

Simulation experiment was conducted to verify the performance of the proposed methods. Different levels of noise were added to video sequences, and the accuracy of the estimated noise level determined by each method was compared.

A. Test Sequences

Noise levels in general videos were estimated using the frame difference (Section 3.1), the proposed method 1 (Section 3.3), and the proposed methods 2-A and 2-B (Section 3.4). The five HDTV $(1,920 \times 1,080)$ video sequences [17] shown in Figure 11 were used in this experiment. Sequence 1 contains the train moves from the back to the front while the camera pans. In Sequence 2 the woman stands at the same position while only the background moves. The background is inset with chroma key. Sequence 3 is a pop music show video. Sequence 3 is called confetti and contains flash. Sequence 4 looks similar video sequence as Sequence 2. The woman stands at the same position while only the background zooms back with chroma key. Sequence 5 shows the teams enter the march and the camera tilts vertically. All sequences included moving objects and various camera actions, such as panning and tilting. Gaussian noise with different standard deviations (1, 3, 5, 7, 9, 11, 13, and 15) was added to the videos.

B. Experimental Results

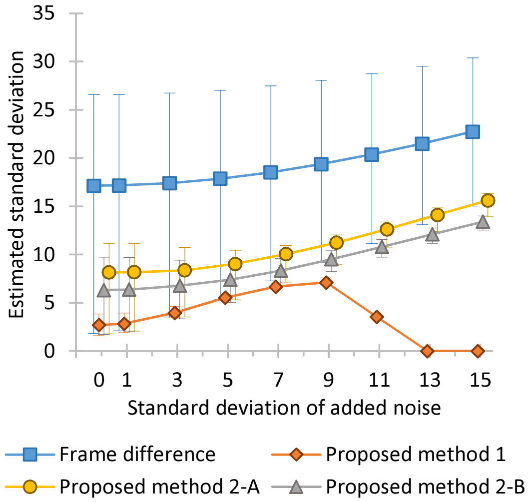
The experimental results are shown in Figures 12 and 13. Figures 12 (a)-(e) show the results for sequences 1-5 respectively. The figures show the estimated standard deviation for each level of added noise. The x-axis is the standard deviation of the noise added to the test sequence, and the y-axis is the estimated standard deviation of the noise in the sequence. The marks show the median values of the estimated standard deviations. If the estimated noise level is correct, the result has the same value as the added noise standard deviation, i.e., $y = x$. The bars indicate the minimum to maximum range of the estimated noise standard deviation, which shows the variation of the results in the sequence.

In Figures 12 (a)-(e), the results for the frame difference method are overestimated and demonstrate large variance. The estimated results for the proposed method 1 are the most accurate and have the smallest dispersion of results. However, the estimation is not possible with the noise standard deviation exceeding 9 because there are few or no appropriate areas for calculating noise standard deviation. The proposed methods 2-A and 2-B returned fewer errors and demonstrate more consistent estimated results than the frame difference. However, large errors tend to occur when the noise standard deviation is less than 3. A comparison of the results for the proposed methods 2-A and 2-B, with and without motion compensation, demonstrates that motion compensation is effective in certain cases. However, it increases the cost significantly because a real-time motion compensation requires large hardware.

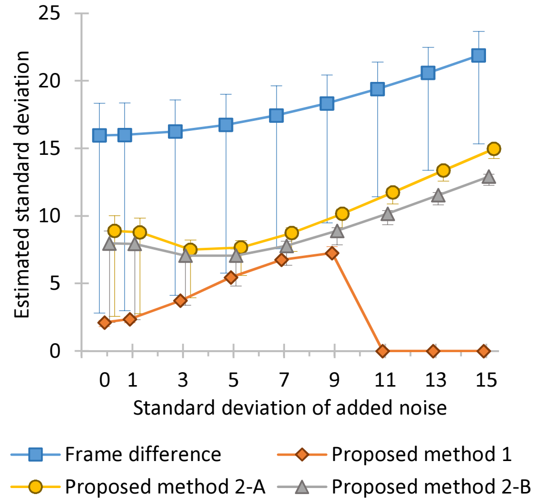
Figure 13 shows the estimated noise standard deviation for all frames of sequence 1 (Figure 12 (a)). Figures 13 (a) and (b) show the estimation results for the proposed methods 2-A and 2-B when the noise level is larger than 9. Here the x-axis is the frame number, and the y-axis is the estimated standard deviation of the noise in the frame. The results become constant if the noise level estimation is correct.

In sequence 1, the train is moving with camera panning from 0 to 150 frames, then the panning stops. The train continues to move during frames 150 to 420. There is no motion in frames 420-450. As shown in Figures 13 (a) and (b), the effect of motion on the estimation result is negligible, and the results become constant.

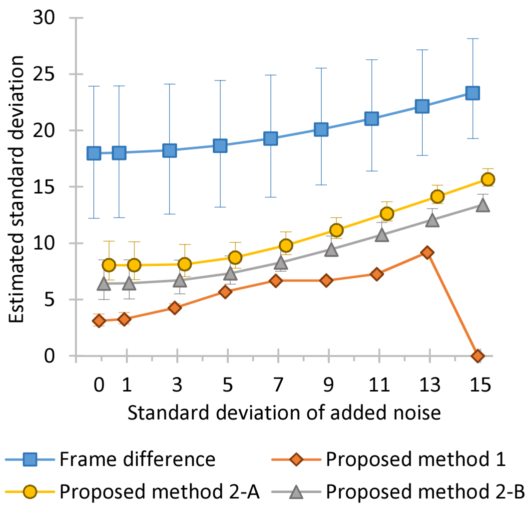
The results for all test sequences are shown in Figures 15-19 respectively. Here the x-axis is the frame number, and the y-axis is the estimated standard deviation of that. All the results show the same tendensies. The frame difference does not show the accurate standard deviation and it changes dramatically depending on the moving objects. The proposed method 1 gives almost accurate standard deviation when the noise standard deviation is lower than 9. However, the proposed method 1 does not work when the standard deviation exceeds 9. The proposed method 2-A produces good results when the standard deviation is higher than7 except for Sequence 5. Sequence 5 has both moving detailed objects and the camera tilting



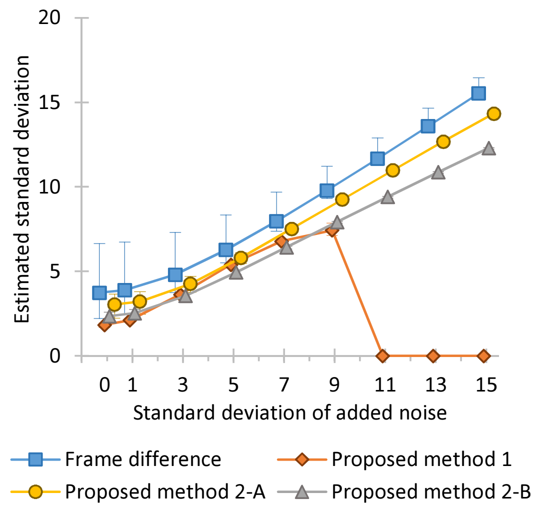
(a) Sequence 1



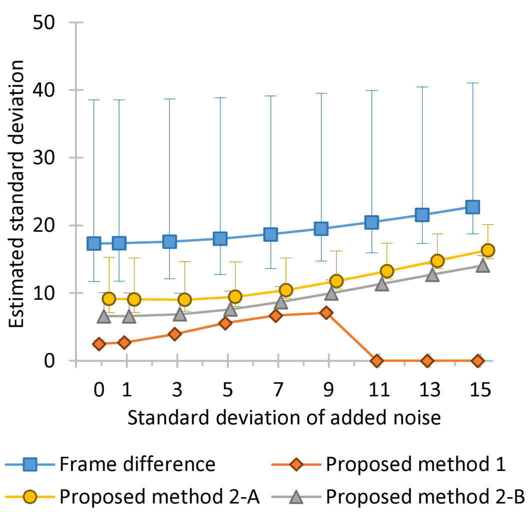
(b) Sequence 2



(c) Sequence 3

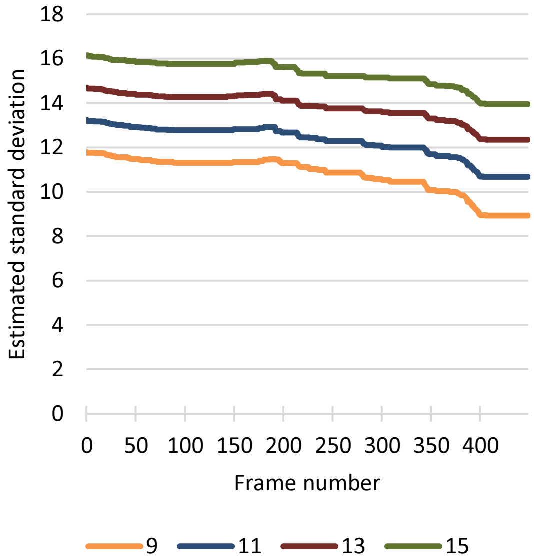


(d) Sequence 4

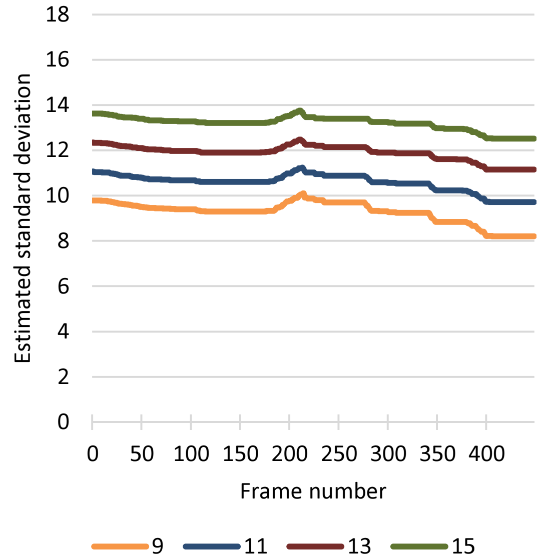


(e) Sequence 5

Figure 12. Results of estimated noise standard deviation. (a) - (e) show the results for sequences 1-5, respectively. The estimated results of all frames of the video sequence are accumulated. The marks show the median values of the estimated standard deviations. The bars indicate the maximum and minimum values.



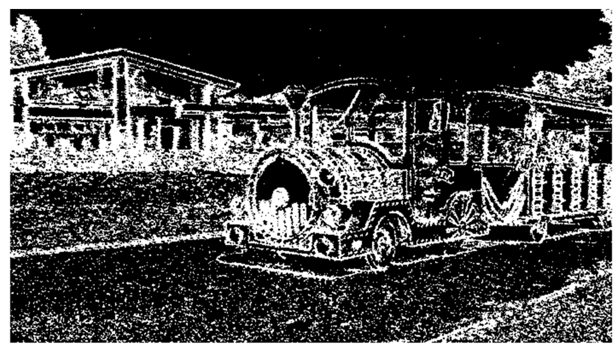
(a) Proposed method 2-A



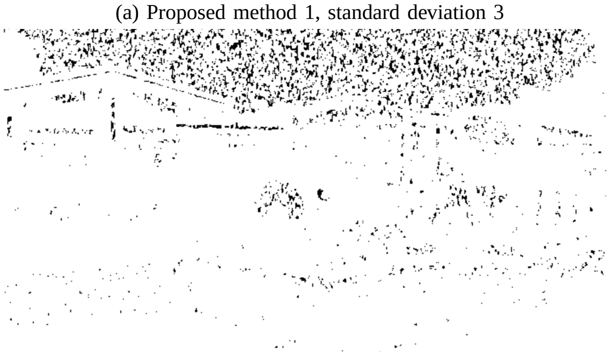
(b) Proposed method 2-B

Figure 13. Results of estimated noise standard deviation in time axis for sequence 1 using the proposed methods (a) 2-A and (b) 2-B

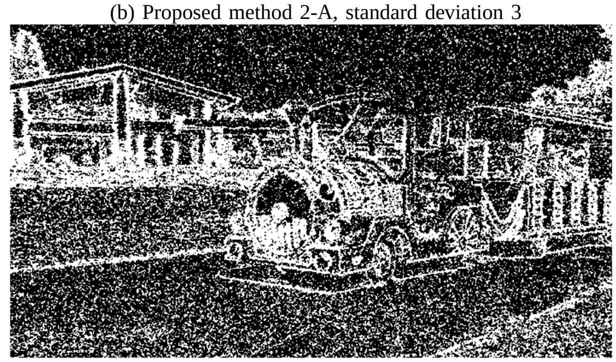
(a) Proposed method 1, standard deviation 3



(b) Proposed method 2-A, standard deviation 3



(c) Proposed method 1, standard deviation 7



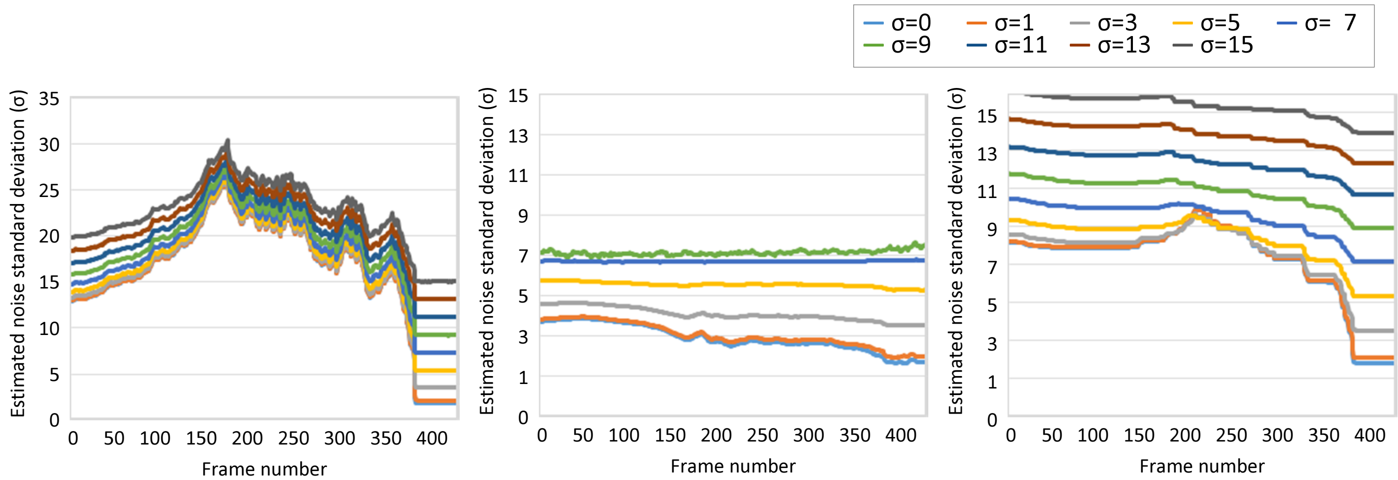
(d) Proposed method 2-A, standard deviation 7

Figure 14. Areas of calculated noise standard deviations for one frame of sequence 1

movement. Two different motions generate frame differences with different properties. A new method should be added to improve performance. This is a future work.

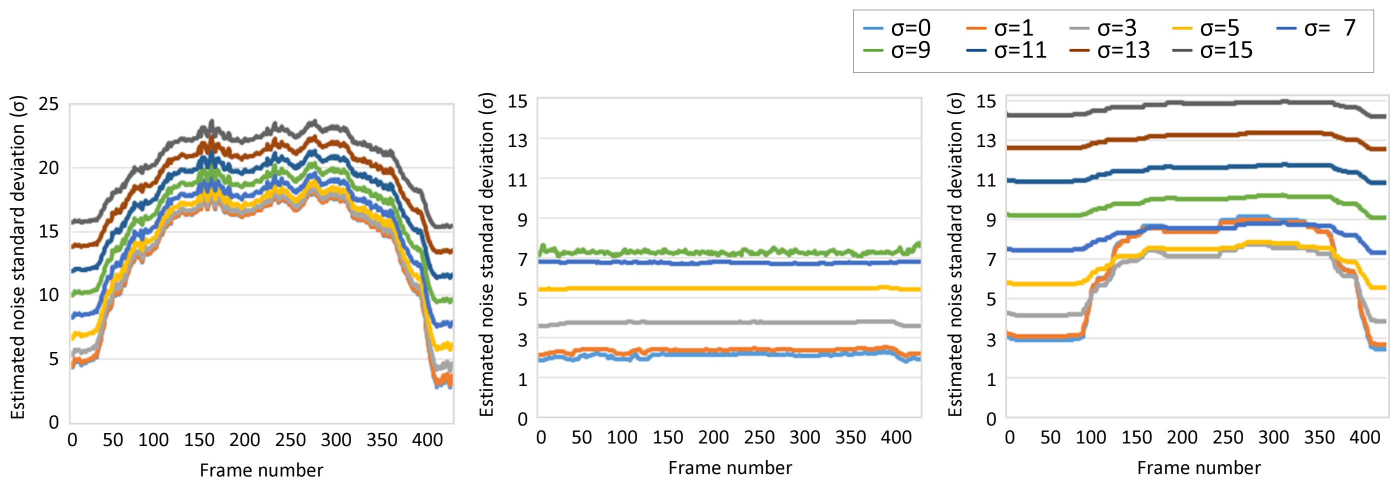
V. DISCUSSION

Comparisons of the areas for noise estimation using the proposed method 1, and the proposed method 2-A are shown in Figure 14. The estimated noise areas for sequence 1 with added Gaussian noise are shown in Figures 14 (a)-(b) (standard deviation 3) and Figures 14 (c)-(d) (standard deviation 7). Here, the white areas are estimated moving areas; thus, only the black areas are used for noise estimation. When comparing Figure 14 (a) with Figure 14 (b), and Figure 14 (c) with Figure 14 (d), the moving areas estimated using the proposed method 1 are thick; however, there are few areas for noise estimation when the noise level is high. Since the proposed method 1 fully



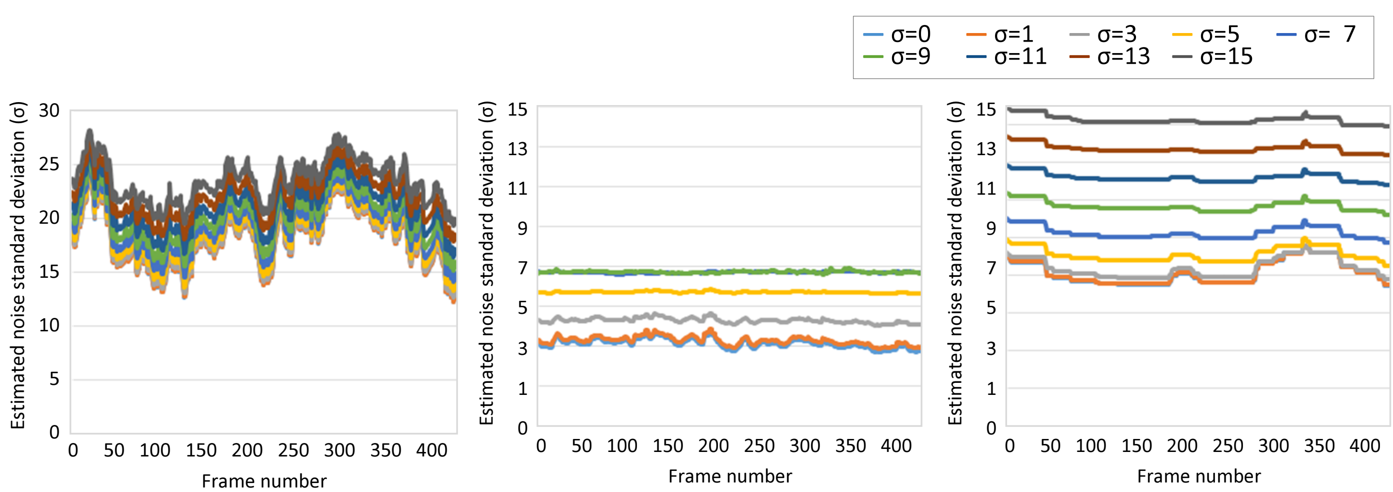
(a) Frame difference (b) Proposed method 1 (c) Proposed method 2-A

Figure 15. Results of estimated noise standard deviation in time axis for sequence 1 using the frame difference (a), the proposed method 1 (b), and the proposed method 2-A (c)



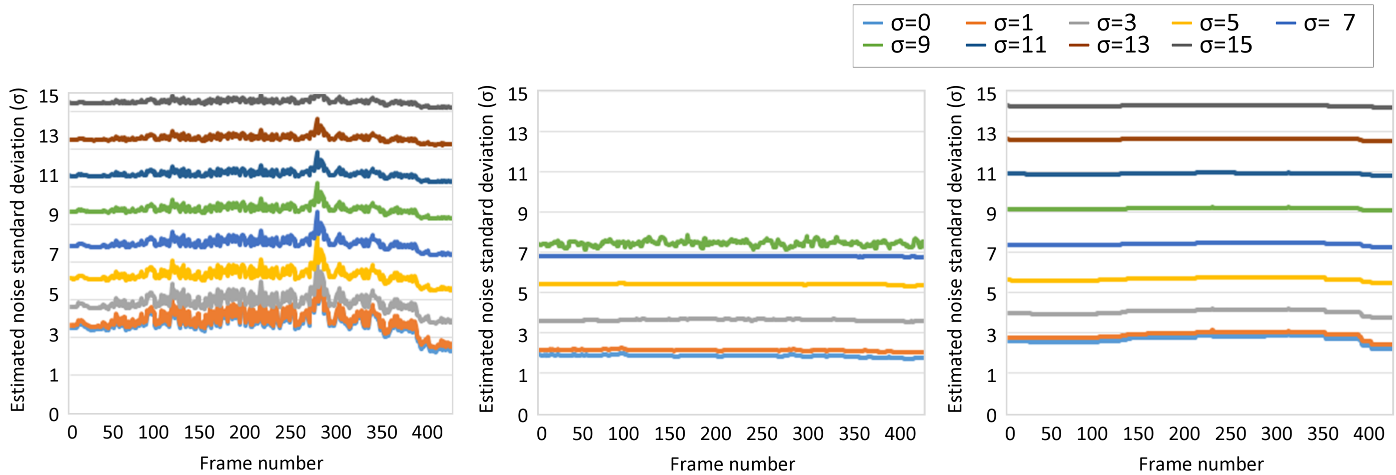
(a) Frame difference (b) Proposed method 1 (c) Proposed method 2-A

Figure 16. Results of estimated noise standard deviation in time axis for sequence 2 using the frame difference (a), the proposed method 1 (b), and the proposed method 2-A (c)



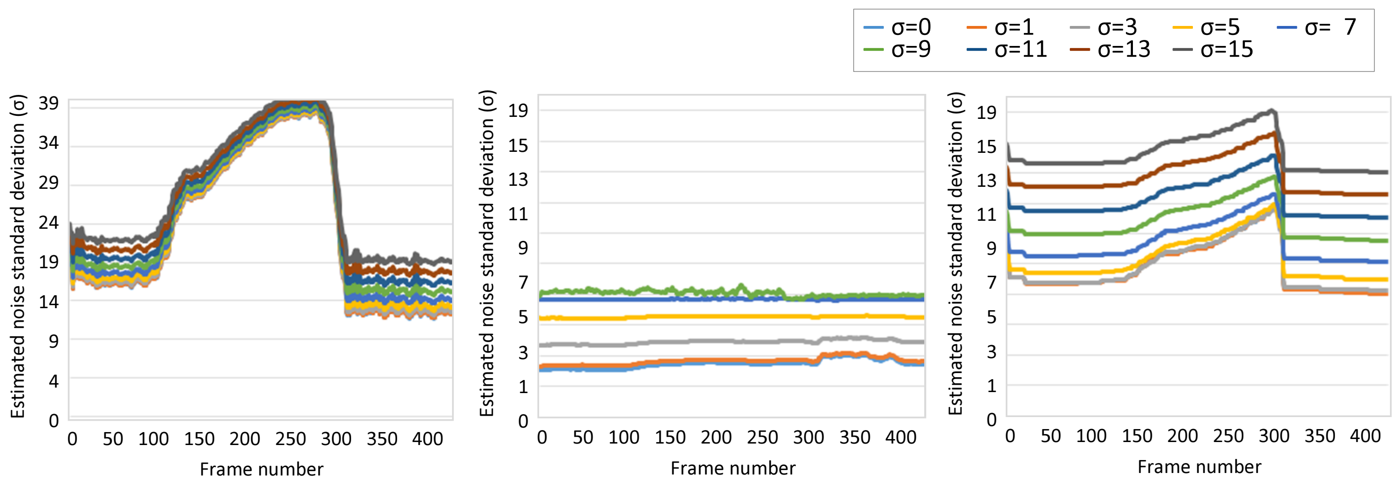
(a) Frame difference (b) Proposed method 1 (c) Proposed method 2-A

Figure 17. Results of estimated noise standard deviation in time axis for sequence 3 using the frame difference (a), the proposed method 1 (b), and the proposed method 2-A (c)



(a) Frame difference (b) Proposed method 1 (c) Proposed method 2-A

Figure 18. Results of estimated noise standard deviation in time axis for sequence 4 using the frame difference (a), the proposed method 1 (b), and the proposed method 2-A (c)



(a) Frame difference (b) Proposed method 1 (c) Proposed method 2-A

Figure 19. Results of estimated noise standard deviation in time axis for sequence 5 using the frame difference (a), the proposed method 1 (b), and the proposed method 2-A (c)

eliminates moving areas, the noise level estimation becomes accurate. However, the noise estimation does not work with high level noise due to few or no available estimation areas. In contrast, the estimated moving areas using the proposed method 2-A are thin; therefore, the moving areas of the frame with high level noise are detectable.

As described in Section IV-B, the proposed method 1 can detect low level noise accurately when the standard deviation is less than 9. However, this method requires improvement to detect high level noise when the standard deviation is higher than 9. In contrast the proposed methods 2-A and 2-B can detect high level noise when the standard deviation is 5 or more. Therefore, we propose combining the proposed methods 1 and 2-A, i.e., when the detected noise level is less than 9, the proposed method 1 is appropriate and when the detected noise level is equal to or higher than 9, the proposed method 2-A is appropriate. Moving compensation can improve noise detection accurately; however, it requires significantly more expensive hardware.

The proposed method 2-A shows higher noise level than the actual noise level. Even if a noise level higher than the actual level is used for the noise reducer, it has little effect on the image quality. When the higher noise level than the actual level is input to the noise reducer the noise reducer works stronger. However, at this noise level: ($\sigma > 9$), there is considerable visual degradation and the effect is difficult to perceive.

In our experiment the proposed method 2-A did not show the good result in Sequence 5. Sequence 5 has mainly three motion factors. They are vertical camera tilting, marching people, and others including noise. The global motion vector can cover the vertical camera tilting. Although the marching people move almost the same direction, each person moves differently. The motion compensation can cover marching peoples' movement as a group. However, the motion compensation cannot cope with each person's movement. If local motion vectors are used, the accuracy of the motion detection would be improved. It would improve precision of the noise level.

However, it requires significantly more expensive hardware and it also increases cost.

VI. Conclusion

In this paper, real-time noise level detection algorithms for videos were proposed. They consist of two ideas because it is difficult to cope with the wide range noise level detection. The proposed method is a combination of the low noise level detection method ($\sigma < 9$) and the high noise level detection ($\sigma \leq 9$). The simulation results demonstrate that the best results can be realized by combining two methods. Although further research is required, the proposed method showed satisfied results. In future, we intend to develop a way to switch between methods automatically and to control NR using the proposed methods. Ultimately, we hope to develop real-time noise reduction hardware that controls noise level parameters automatically.

References

[1] C. Mori and S. Gohshi, "Real-time noise level detection for general video," in *CONTENT 2019, The Eleventh International Conference on Creative Content Technologies*, 2019, pp. 1–6.

[2] M. Kazubek, "Wavelet domain image denoising by thresholding and wiener filtering," *IEEE Signal Processing Letters*, vol. 10, no. 11, pp. 324–326, 2003.

[3] A. Pizurica, V. Zlokolica, and W. Philips, "Noise reduction in video sequences using wavelet-domain and temporal filtering," in *Wavelet Applications in Industrial Processing*, vol. 5266. International Society for Optics and Photonics, 2004, pp. 48–60.

[4] N.-X. Lian, V. Zagorodnov, and Y.-P. Tan, "Video denoising using vector estimation of wavelet coefficients," in *2006 IEEE International Symposium on Circuits and Systems*. IEEE, 2006, pp. 2673–2676.

[5] I. W. Selesnick and K. Y. Li, "Video denoising using 2d and 3d dual-tree complex wavelet transforms," in *Wavelets: Applications in Signal and Image Processing X*, vol. 5207. International Society for Optics and Photonics, 2003, pp. 607–619.

[6] A. Pizurica, V. Zlokolica, and W. Philips, "Combined wavelet domain and temporal video denoising," in *Proceedings of the IEEE Conference on Advanced Video and Signal Based Surveillance, 2003.* IEEE, 2003, pp. 334–341.

[7] N. Gupta, M. Swamy, and E. I. Plotkin, "Low-complexity video noise reduction in wavelet domain," in *IEEE 6th Workshop on Multimedia Signal Processing, 2004.* IEEE, 2004, pp. 239–242.

[8] R. O. Mahmoud, M. T. Faheem, and A. Sarhan, "Comparison between discrete wavelet transform and dual-tree complex wavelet transform in video sequences using wavelet-domain," *INFOS2008*, pp. 20–27, 2008.

[9] L. Jovanov, A. Pizurica, S. Schulte, P. Schelkens, A. Munteanu, E. Kerre, and W. Philips, "Combined wavelet-domain and motion-compensated video denoising based on video codec motion estimation methods," *IEEE transactions on circuits and systems for video technology*, vol. 19, no. 3, pp. 417–421, 2009.

[10] F. Luisier, T. Blu, and M. Unser, "Sure-let for orthonormal wavelet-domain video denoising," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 20, no. 6, pp. 913–919, 2010.

[11] J. C. Brailean, R. P. Kleihorst, S. Efstratiadis, A. K. Katsaggelos, and R. L. Lagendijk, "Noise reduction filters for dynamic image sequences: A review," *Proceedings of the IEEE*, vol. 83, no. 9, pp. 1272–1292, 1995.

[12] V. Zlokolica, A. Pizurica, and W. Philips, "Noise estimation for video processing based on spatio-temporal gradients," *IEEE Signal Processing Letters*, vol. 13, no. 6, pp. 337–340, 2006.

[13] V. Kamble and K. Bhurchandi, "Noise estimation and quality assessment of gaussian noise corrupted images," *IOP Conference Series: Materials Science and Engineering*, vol. 331, no. 1, pp. 1–10, 2018.

[14] M. Ghazal, A. Amer, and A. Ghrayeb, "A real-time technique for spatio–temporal video noise estimation," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 17, no. 12, pp. 1690–1699, 2007.

[15] S.-M. Yang and S.-C. Tai, "A fast and reliable algorithm for video noise estimation based on spatio-temporal sobel gradients," in *International Conference on Electrical, Control and Computer Engineering 2011 (InECCE).* IEEE, 2011, pp. 191–195.

[16] K. Miyamae and S. Gohshi, "Noise level detection in general video," in *2018 International Workshop on Advanced Image Technology (IWAIT)*, Jan 2018, pp. 1–4.

[17] "Ite/arib hi-vision test sequence 2nd edition," 2009.

[18] M. J. B. Wilhelm Burger, *Principles of Digital Image Processing: Fundamental Techniques*. Springer, 2009, pp. 144–145.

iaria journals

www.iariajournals.org

International Journal On Advances in Intelligent Systems
issn: 1942-2679

International Journal On Advances in Internet Technology
issn: 1942-2652

International Journal On Advances in Life Sciences
issn: 1942-2660

International Journal On Advances in Networks and Services
issn: 1942-2644

International Journal On Advances in Security
issn: 1942-2636

International Journal On Advances in Software
issn: 1942-2628

International Journal On Advances in Systems and Measurements
issn: 1942-261x

International Journal On Advances in Telecommunications
issn: 1942-2601