EMITTER International Journal of Engineering Technology
Vol. 7, No. 1, June 2019
ISSN: 2443-1168

AI-Josyu: Thinking Support System in Class by Real-time Speech Recognition and Keyword Extraction

Kyohei Matsumoto[1,2], Takafumi Nakanishi[1,3], Toshitada Sakawa[4], Kengo Onodera[5], Shinichiro Orimo[6], Hiroyuki Kobayashi[6]

[1] GLOCOM, International University of Japan
Harks Roppongi Bldg. 2nd floor, 6-15-21 Roppongi, Minato-ku, Tokyo 106-0032
kmatsumoto@glocom.ac.jp, takafumi@glocom.ac.jp
[2] University of Tsukuba
1-1-1 Tennodai, Tsukuba, Ibaraki 305-8577
matsumoto.kyohei.ws@alumni.tsukuba.ac.jp
[3] Musashino University
3-3-3 Ariake, Koto-ku, Tokyo
takafumi.nakanishi@ds.musashino-u.ac.jp
[4] Sakawa Co., Ltd.
2215-1 Minamigata, To-on-shi, Ehime 791-0301
toshi@sakawa.net
[5] TerraLin Create Co., Ltd.
#307, 1-19-15 Nakanoshima, Tama-ku Kawasaki-shi, Kanagawa 214-0012
onodera@tlc.co.jp
[6] Hirayama Elementary School
4-8-6 Hirayama, Hino-shi, Tokyo 191-0043
school@e-hirayama.hino-tky.ed.jp, principal@e-hirayama.hino-tky.ed.jp

Abstract

In this paper, we present a thinking support system, *AI-Josyu*. This system also operates as a class support system which helps to teachers for lightening their work. AI-Josyu is implemented based on media-driven real-time content management framework. The system links real world media and legacy media contents together. In resent years, it is easier to collect a large amount of various kinds of data which are created with sensors in the real world. The system realizes interconnection and utilization of legacy media contents. The legacy media contents are generated and scattered on the Internet. The framework has four modules, which are called “acquisition,” “ extraction,” “selection,” and “retrieval.” The real world media and the legacy media contents are interconnected by these modules. This interconnection includes semantic components. This system records teacher's voice of its lecture in real time and presents retrieved legacy media contents corresponding to subject of the lecture. By this presentation, preparing of the legacy contents is not required. This system automatically retrieves and shows the legacy media contents. This system helps students to understand contents of the lecture. In addition, the system attends to expansion of ideas. We constructed the system and conducted the demonstration in class. It shows that the system is helpful to teacher and students for expansion of thinking.

Keywords: thinking support system, class support, interconnection, media-driven, content management

1. INTRODUCTION

In recent years, it is easier to collect a large amount of various kinds of data which are created with sensors in the real world. These sensors can detect and generate real world events in real-time as media data. On the other hand, there is a large amount of legacy media contents on the Internet. Although users can utilize these legacy media contents progressively, the legacy contents are too huge to utilize. It is caused by scattering contents on the Internet that the difficulty of utilization according to their purpose, task, or interest. Therefore, it is important to link real world media and legacy media contents in real time.

To construct the interconnection between media data generated from real-world and legacy media contents scattered on the Internet, it is necessary that semantic metadata which represents real media data and legacy media contents cross-sectionally. Some extracting method of semantic metadata, also known as various types of recognition method, has been developed in the field of machine learning (e.g., [1]). We have already proposed a media-lexicon transformation operator [2][3][4]. This operator extracts weighted words as the semantic metadata. The weighted words represent impressions according to type of media, such as music, images, and videos. In order to retrieve metadata, this operator collaborates with real world sensors.

In this paper, we present a thinking support system, *AI-Josyu* (Josyu means “assistant” in Japanese). This system also operates as a class support system which helps to teacher for lightening their work. AI-Josyu is implemented based on a media-driven real-time content management framework[5] for interconnection between real world media and legacy media contents. The framework has four modules, which are called “acquisition,” “extraction,” “selection,” and “retrieval.” The acquisition module stores media data from real world. The media data is generated with a lot of sensors in real time. The extraction module gives semantic metadata to that media data. The metadata relates events which are occurring in real world. The metadata is extracted as semantic words. This module can be implemented with the recognition method and the media-lexicon transformation operator. The selection module determines some contexts underneath the extracted metadata. This module makes extension of the metadata. The context is selected among the extended metadata. The context serves as a query for the legacy system. The retrieval module gathers legacy contents which are related to contexts. These modules realize semantic interconnection between real-world media data and legacy contents. The framework links real world media and legacy media contents together. The legacy media content is collected automatically and semantically from the Internet in response to the real events that represented as the metadata.

We also implement and demonstrate a thinking support system, *AI-Josyu*, used in class. This system records teacher's voice of its lecture in real time and presents retrieved legacy media contents corresponding to subject of the lecture. This system projects the retrieved contents on a blackboard. By this projection, preparing of the legacy contents is not required. This system helps students to understand contents of the lecture and expand their thinking.

This paper is composed of the following. In section 2, we present some related works. In section 3, we explain the media-driven real-time contents management framework. In section 4, we present the details of the thinking support system. In section 5, a system usage is expressed. In section 6, we show the demonstration of the thinking support system in actual class lecture. Finally, in section 7, we present the conclusion.

2. RELATED WORKS

The speech recognition has been developed in the field of machine learning recently [1]. This technology has been applied to automatic transcription for students [6]. Some recognition techniques are specialized for regarding certain language such as Indonesian [7]. The producing transcripts of a lecture is beneficial for learning and teaching [8]. The speech recognition has been used for quickly searching keywords to retrieve text or video lecture content [8][9][10]. Generally, the speech recognition is used for the note-taking in the classroom. Some classroom note-taking systems for hearing impaired students are proposed and implemented [11][12][13].

Clicker is available as a student response system which is one of the class support system [14][15]. Clicker helps instructors in the lecture, estimates student level of understanding, and provides feedback to student questions [14].

Semantic-computing between the real-world and the cyber-world is also important to interconnection of these world. A calculating similarity-ranking method on semantic computing is applied to providing information services [16].

Our proposed system aims at not only automatic transcription but also supporting expansion of thinking. Our system provides materials of thinking via legacy systems. Our system focuses on recording lectures and sharing tips for other teachers.

3. OVERVIEW OF MEDIA-DRIVEN REAL-TIME CONTENT MANAGEMENT FRAMEWORK

In this section, we explain the media-driven real-time content management framework. This framework provides an interconnection between media data generated from real-world and legacy media contents scattered on the Internet.

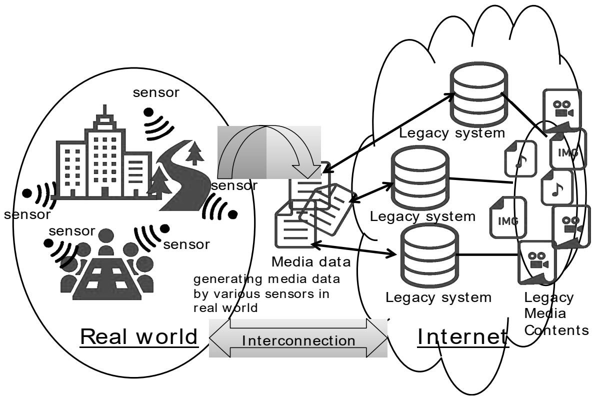

Figure 1. Media data interconnects between real world and the Internet.

First, we show an overview of the framework in section 3.1, and then four modules, "acquisition," "extraction," "selection," and "retrieval," which are component of the framework, are explained in section 3.2.

3.1. OVERVIEW

Figure 1 shows an overview of interconnection between real world and the Internet.

In the real world, there are many types of sensors. These sensors make production of media data constantly. Media data has various types corresponding to real events. For example, it is formed as images, videos, etc. It is undoubtful that the generated media data experesses real events. Therefore, media data analysis is important for real world event analysis.

On the other hand, there is a large amount of legacy media contents managed by legacy systems. These systems and contents are scattered on the Internet. The legacy system contributes to sharing, retrieval, and integration of the legacy media contents.

In order to utilize the legacy media contents, it is required that a seamless connection between the media data and the legacy media contents. By this connection, we can retrieve and utilize legacy media contents without any special action about legacy systems.

This seamless connection is related to the ubiquitous environment. In this environment, there are a lot of devices which include sensors to observe our actions. That is, in such environment, sensors surrounding our lives are important to digitize all real-world events, give events their contexts, and utilize legacy media contents at all times.

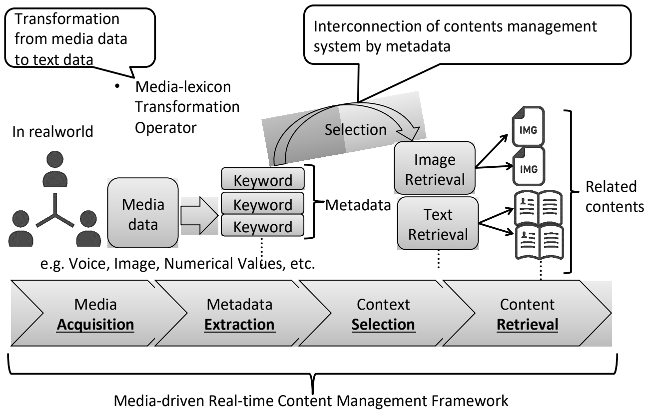

Figure 2. Four modules of media-driven real-time content management framework.

The one of the important issues is how to seamlessly connect these processes for realization of ubiquitous environment. In the next section, we propose a new framework to realize such a seamless connection.

3.2. FOUR MODULES OF MEDIA-DRIVEN REAL-TIME CONTENT MANAGEMENT FRAMEWORK

Figure 2 shows four modules of the media-driven real-time content management framework. The system links real world media and legacy media contents together.

This framework contains four modules, "acquisition," "extraction," "selection," and "retrieval." These modules are connected seamlessly.

(1) Media Acquisition

The acquisition module stores media data from real world. The media data is generated with a lot of sensors in real time. Each media data has various types of format such as image, voice, video, etc.

For examples of the acquisition module, microphones record audio media data from voice. And cameras also capture images and videos as media data. This module creates and stores a large amount of media data constantly. This operation realizes digitization of the real events.

(2) Metadata Extraction

The extraction module gives semantic metadata to stored media data. The metadata relates events which occurring in real world. The metadata is converted into semantic words for accessing legacy systems.

For extraction of metadata, some recognition methods have been developed in the field of machine learning (e.g., [1]). These methods provide words representing media data. For example, the speech recognition creates a transcription from voice data. As with the speech recognition, the image recognition gives words, phrases, and sentences to image data.

A media-lexicon transformation operator [2][3][4], which is our proposed operator, can be applied to this module. This operator can extract impressions as weighted words. The media-lexicon transformation operator is generally formulated as follows:

ML(Md): Md → Ws,

ML: Media-Lexicon transformation operator,

Md: Media data, Ws: Word set.

Figure 3 shows an over view of the media-lexicon transformation operator. The media-lexicon transformation operator generates *m*-dimensional vector characterized with weighted words which located on common word space. The media-lexicon transformation operator has two steps; the first step is the feature extraction, and the second step is the mapping operator. The feature extraction extracts *n*-dimensional vector characterized with features. The mapping operator converts *n*-dimentional feature vector into *m*-dimentional vector.

(3) Context Selection

The selection module determines some contexts underneath the extracted metadata. The context also represents as words in the common word space. This module makes extension of the metadata. The context is selected among the extended metadata. The context serves as a query for the legacy system.

This module includes semantic computing of words. It calculates similarity, relationship, and distance of words. This function provides selection and extension of metadata.

(4) Content Retrieval

The retrieval module gathers legacy contents which are related to contexts. The legacy contents are scatterd on the Internet and can be extracted via the legacy systems.

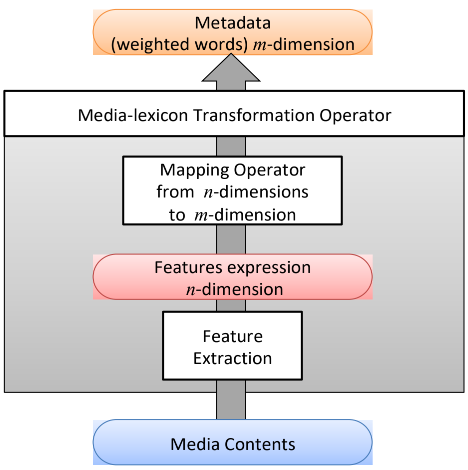

Figure 3. an overview of the media-lexicon transformation operator.

These modules realize semantic interconnection between real-world media data and legacy contents. The framework links real world media and legacy media contents together. The legacy media content is collected automatically and semantically from the Internet in response to the real events that represented as the metadata.

4. THINKING SUPPORT SYSTEM USED IN CLASS APPLYING OUR FRAMEWORK

In this section, we show an implementation of the thinking support system, *AI-Josyu*. It is based on the media-driven real-time content management system framework. This system records teacher's voice of its lecture in real time and presents retrieved legacy media contents corresponding to subject of the lecture. This system projects the retrieved contents on a blackboard. By this projection, preparing of the legacy contents is not required. This system helps students to understand contents of the lecture and expand their thinking.

Figure 4 shows an overview of our thinking support system. This system consists of four steps.

- [Step 1: Acquisition module] Acquisition of teacher’s voice

  A microphone is available to record the teacher’s voice of the lecture. The acquisition module stores the voice. The voice data is digitized on the system.

- [Step 2: Extraction module] Extraction of keywords

  This module makes a transcription from the recorded voice and extracts some keywords from the transcription automatically. This module is implemented the media-lexicon transformation operator and the speech recognition methods. For AI-Josyu, Web Speech API provided by Mozilla is implemented as this module.

- [Step 3: Selection module] Selection and extension of metadata

  A teacher can select the keywords suggested by the previous module. The selection module suggests related words of the selected keyword by semantic computing. In *AI-Josyu*, we use Word2Vec model [17][18][19] in the semantic computing function.

- [Step 4: Retrival module] Retrieval of images

  A teacher can select the keywords and the related words for accessing legacy systems. This module retrieves images regarding the selected keyword and the related word via the legacy systems.

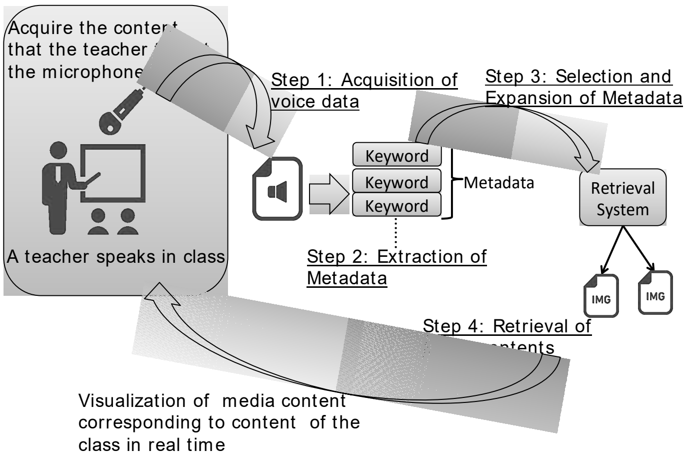

Figure 4. An overview of our thinking support system, *AI-Josyu*.

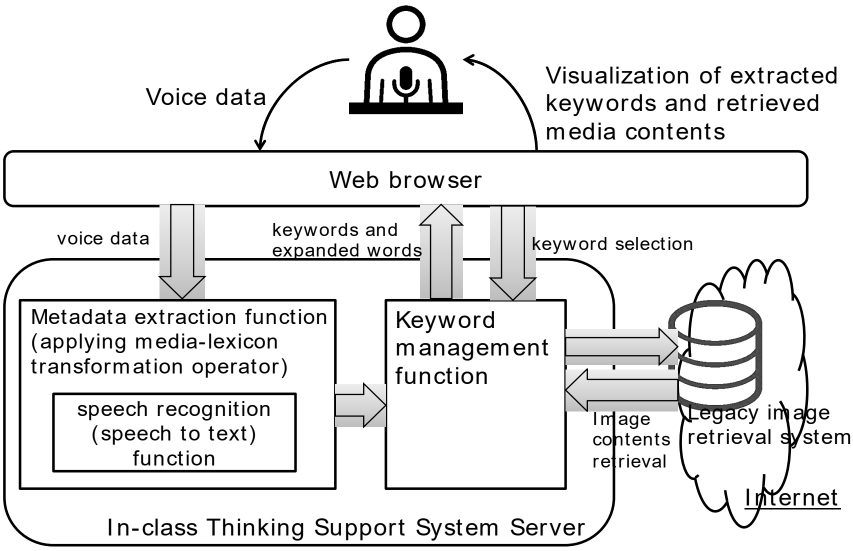

Figure 5. A realization of our thinking support system used in class.

This system projects the retrieved contents on a blackboard. By this projection, preparing of the legacy contents is not required for teachers. This system helps students to understand contents of the lecture and expand their thinking.

Figure 5 shows a structure of *AI-Josyu*. *AI-Josyu* is running on a Web browser. It is expected that the UI of *AI-Josyu* is projected on the blackboard. A microphone is available to record the teacher's voice of the lecture. Metadata extraction function has speech recognition function. It conducts a transcription and extracts keywords. The related words are provided by the keyword management function. The image contents are also provided via the legacy system. A teacher can show the retrieved contents to the students immediately.

To extend keywords into related words, we use Word2Vec model, which converts words into word embeddings as a vector representation and provides relationships among the words. This model retrieves words related to the selected keyword. We adopt a pre-trained model with articles of Wikipedia written in Japanese.

5. USAGE SCENARIOS

We give an example of storyline using *AI-Josyu* in a lecture. This scenario describes the effectiveness of *AI-Josyu*, the thinking support system, and the media-driven real-time content management framework. We give an example of history lecture. Each figure, among Figure 6, 7, 8, and 9, shows role of each module. These figures are screen projected on the blackboard. These are generated and provided by *AI-Josyu.*

First figure of example, figure 6, shows a part of the acquisition module. This screen is first view of starting *AI-Josyu*. The system recognizes automatically teacher's utterances in real-time. In this example, the teacher said that "Toyotomi Hideyoshi was a military commander who played an active part in the Azuchi-Momoyama period since the Sengoku Period" in Japanese. Then, the system displays a transcription of recorded voice data at the left upper.

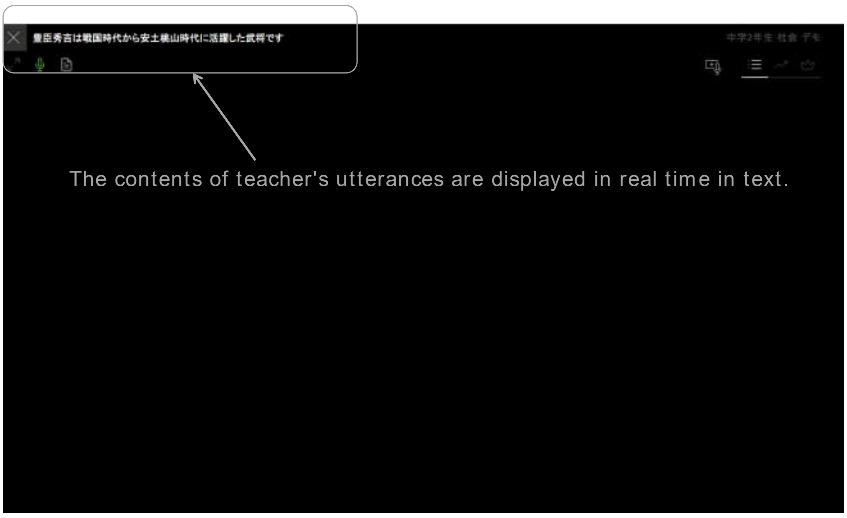

Figure 6. The acquisition module of *AI-Josyu* recognizes voice data and displays a transcription automatically.

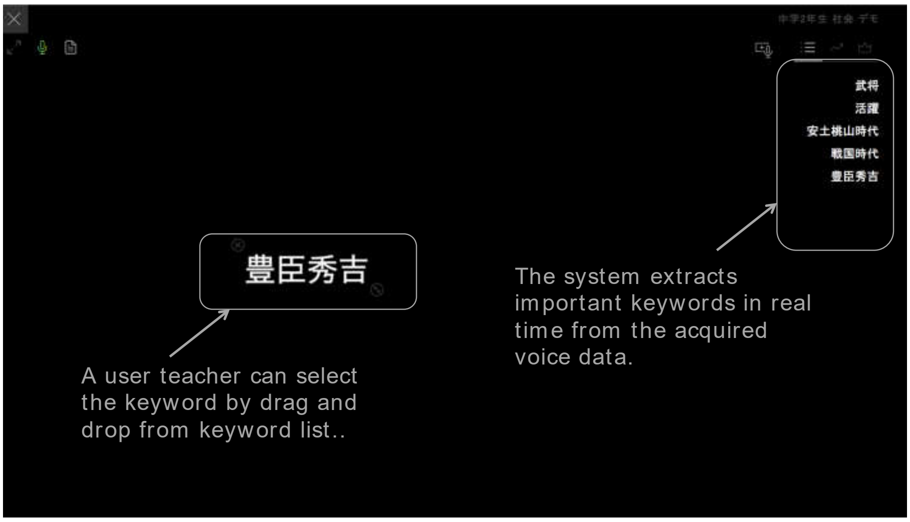

Figure 7. The extraction module of *AI-Josyu* displays keywords extracted from recorded voice data.

Figure 7 shows a function of the extraction module. The system provides keyword list at the right. The system extracts keywords and ranks keywords according to their importances calculated by the keyword management function. The more important keyword is located on the upper in the list. In this example case, the system extracts 5 keywords from the recorded voice data. The extracted keywords are “Japanese military commander,” “activity,” “Azuchi-Momoyama period” (that is one of the Japanese periods), “Sengoku Period” (that is also one of the Japanese periods), and “Toyotomi Hideyoshi”. A teacher can select a focused keyword of the list by drag and drop. In this example, “Tototomi Hideyoshi” is selected and located by the teacher.

Figure 8 shows a part of the selection module. The system draws a star network repserenting relation of words. The relation is calculated semantically. In this figure, a teacher selects “Toyotomi Hideyoshi” as mentioned previously. The system shows semantic related words, "Conquering Kyushu," "Tensei" (that is one of the Japanese periods), "Toyotomi Hidetsugu" (the nephew of Hideyoshi), "Conquering Odawara," and "Hideyoshi."

Figure 9 shows an example of accessing the legacy system with the retrieval module. The system retrives and displays a related legacy contents via legacy systems. The current implementation of AI-Josyu can access image retrieval system. In this example, the system retrieves images related to “Toyotomi Hideyoshi” via the legacy image retrieval system. Finally, the teacher selects a portrait of “Toyotomi Hideyoshi” from retrieved images.

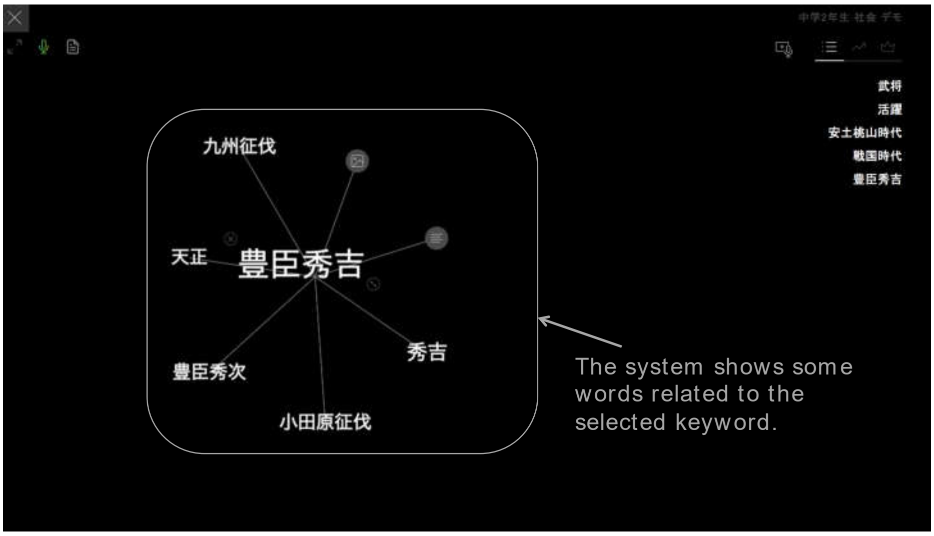

Figure 8. The selection module of *AI-Josyu* draws words network related to selected keyword “Toyotomi Hideyoshi.”

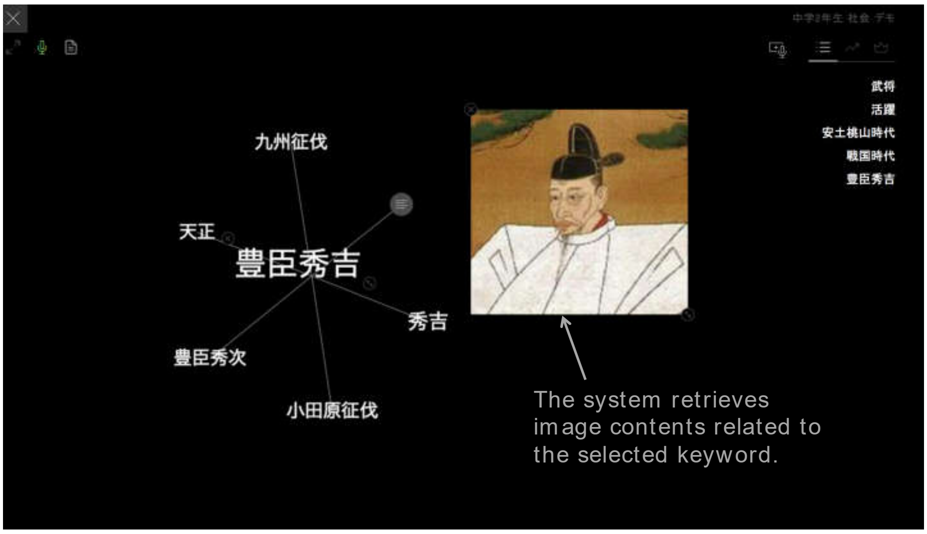

Figure 9. The system accesses legacy image retrieval system.

6. DEMONSTRATION IN ACTUAL CLASS

We demonstrated the thinking support system, *AI-Josyu*, in actual class lecture. We are collaborating with Hirayama Elementary School, on Hino City, Tokyo. The system is used in 3 kind of class. First subject is geology, second is Asuka era of Japanese history, and third is human body.

6.1. EXPERIMENTAL SETUPS AND ENVIRONMENTS

A wireless lapel microphone as sensor is attached on teacher's lapel. A projector connected with a laptop is installed at a distance of a few yards from the blackboard.

The teacher teaches to around 30 students on each lecture. Any microphone is not installed on the side of the students. Therefore, this system acquires only teacher's voice.

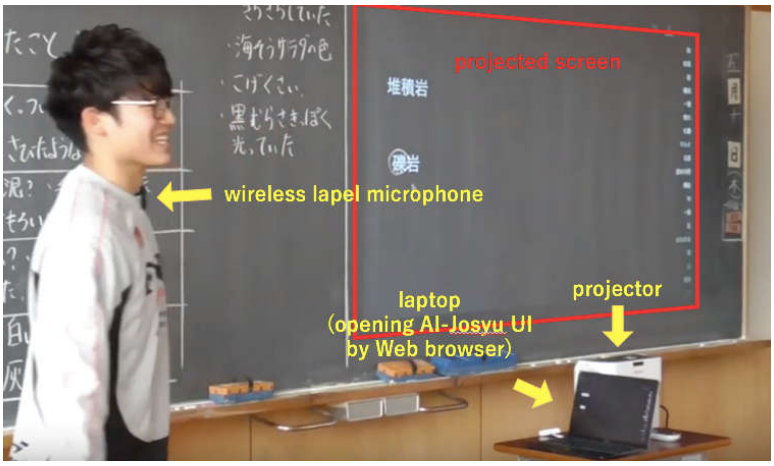

Figure 10. Experimental setups for using AI-Josyu prototype.

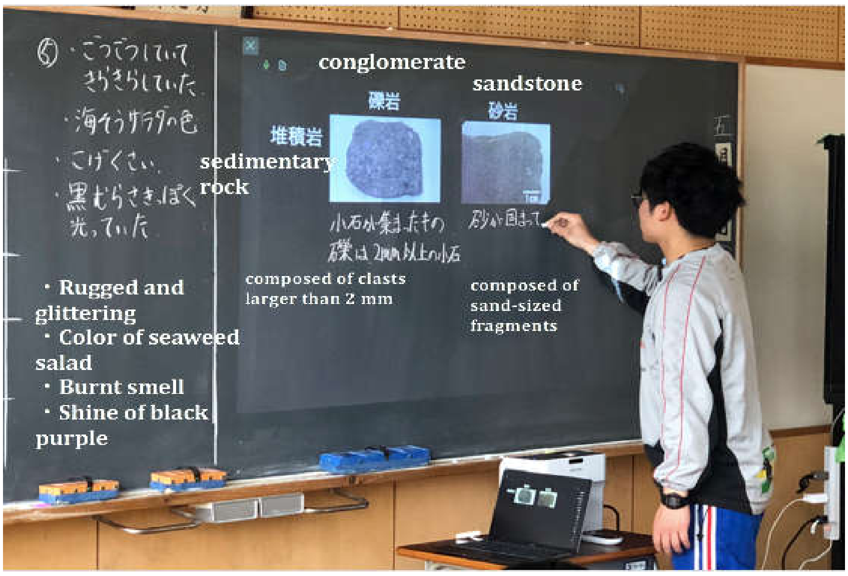

Figure 11. An example demonstration in geology.

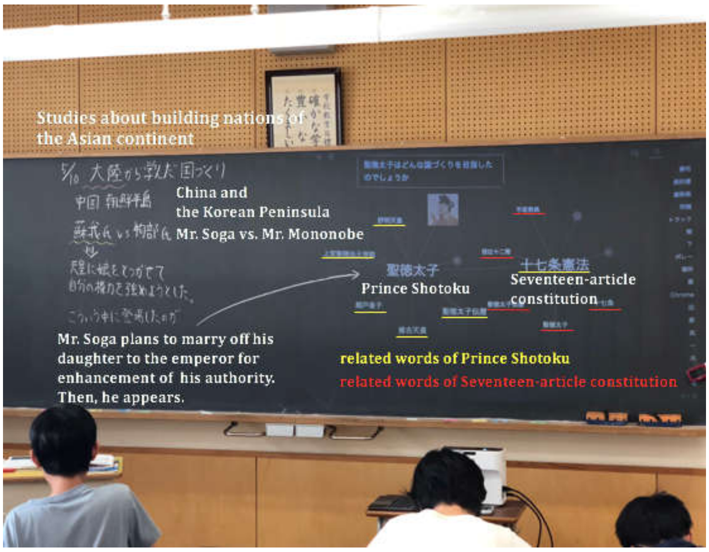

Figure 11. A demonstration in Japanese history. Related words support expansion of thinking.

6.2. DEMONSTRATION IN GEOLOGY LECTURE

Figure 11 shows that a teacher utilizes the legacy image retrieval system for the geology lecture. The system records teacher's voice and recognizes words of his talk by the speech recognition technology. Then, the system calculates importance of words and suggests keywords. The teacher selected some keywords, "conglomerate", "sandstone", and "sedimentary rock", which are extracted automatically from teacher's voice. The system retrieves instantly stone images from selected keywords and shows them on the blackboard. The teacher is able to describe without preparing images. These images help the students for understanding.

These processes are operated in real time by the media-driven real-time content management framework. Our proposed system operates via the legacy systems. Therefore, our system realizes reuse and utilization of the huge legacy contents which are provided by the legacy systems.

6.3. DEMONSTRATION IN JAPANESE HISTORY LECTURE

Figure 12 shows that it is utilized for understanding "Prince Shotoku (Shotoku Taishi)". The extracted keywords by AI-Josyu are located on right side of the blackboard. These keywords are extracted depending on contexts of this lecture. Then, the teacher selects a main keyword, "Prince Shotoku". This main keyword is located on center, and his related words are located around the main keyword. These words are provided by the thinking support system which includes the keyword management function. These related words indicate what was he doing, who is his related person, and etc. These related words cause students to recall related previous lectures and be interested about the keywords more deeply. Thus, this system supports to expansion of thinking with the keyword management system.

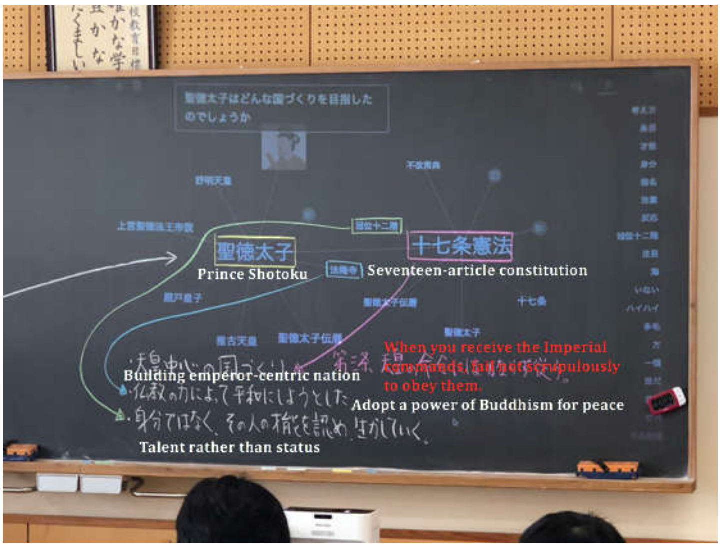

Figure 13. A teacher overwrites descriptions on the screen.

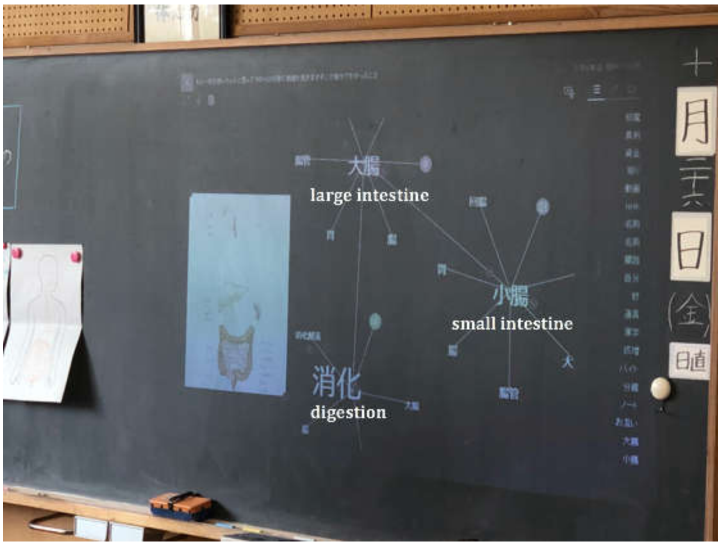

Figure 14. A demonstration of human body lecture.

Figure 13 shows that the teacher overwrites some descriptions on the screen. This system is projected on the blackboard. The teacher can overwrite with chalk as necessary.

6.4. DEMONSTRATION IN HUMAN BODY LECTURE

Figure 14 shows the case of human body. The system retrieves images and displays on the screen. The teacher teaches relations of human body using keywords and related words. As internal organs influence each other, it is important to represent relations between keywords of human body. Figure 15 shows relations of each word. As the case of Japanese History lecture, the teacher overwrites arrows, other keywords, and notes on the screen for description.

6.5. INTERVIEW AND DISCUSSION ON USING AI-JOSYU PROTOTYPE

We ask teachers how about this system after using it. We had a discussion about its usability and its performance.

Regarding the usability, teachers said; “it is easy for me to use this system. The system suggests visually what is important and how to think about the keywords. Extracting keywords automatically and drawing word relationship as the network, the system helps students to set a goal of lecture and be engaged in understanding the subject of lecture. It is possible to connect with ideas of students and provided related keywords. The visual content has effectiveness for some students which requires a special support.”

Furthermore, we ask them the performance of system. The answer is following; “the five related words are sometimes not expected. However, the additional list of related words satisfies me (as shown in Figure 16). In addition, we expect to acquire metadata of students’ voice for realization of interactive lecture. If this system extracts keywords of students’ voice, it is possible to extend their knowledges more effectively.”

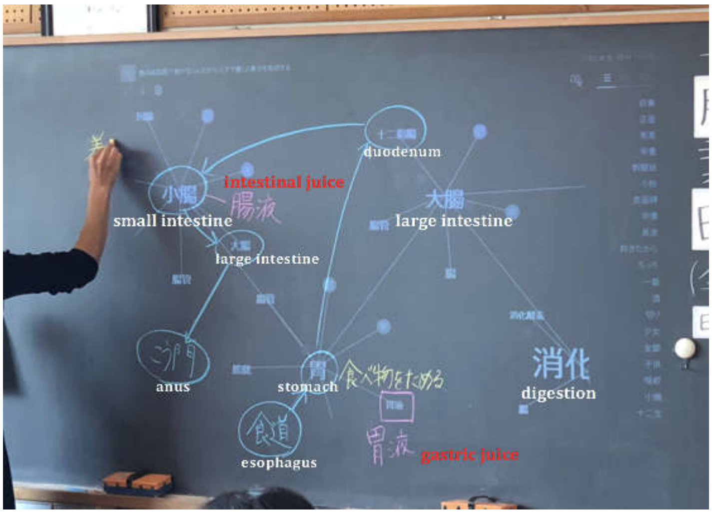

Figure 15. A teacher teaches relations using keywords and related words.

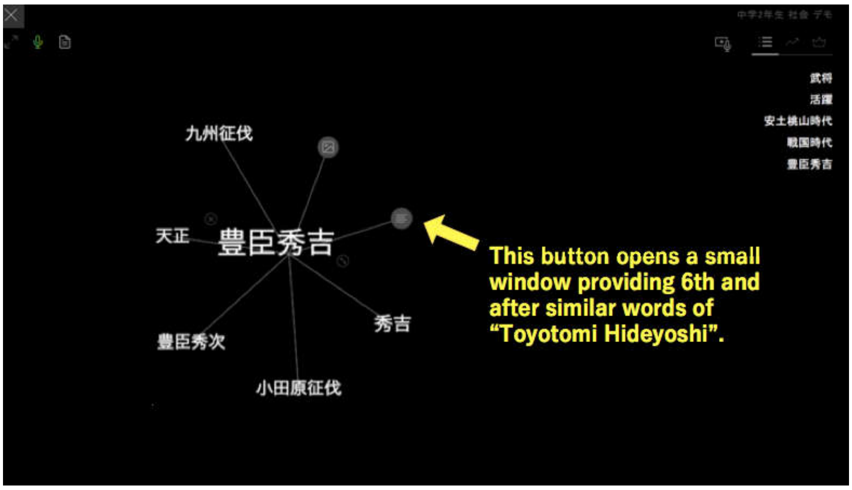

Figure 16. Additional related words button

7. CONCLUSION

In this paper, we presented a thinking support system, *AI-Josyu*. This system based on our proposed new framework, the media-driven real-time content management framework. The system links real world media and legacy media contents together. The framework realizes interconnection instead of a gap real media data and legacy media contents. By this framework, it is possible to make seamless interconnection and convert real events into these metadata constantly.

We also presented the prototype system and demonstrated it in actual lectures. This system records teacher's voice of its lecture in real time and presents retrieved legacy media contents corresponding to subject of the lecture. This system projects the retrieved contents on a blackboard. By this projection, preparing of the legacy contents is not required. This system helps students to understand contents of the lecture and expand their thinking.

As our future works, we will implement translation to our system. Current system is only available in Japanese. Therefore, we should make a suitable word2vec model for this system We will connect our system to various kinds of legacy system that is not only image but also audio, video, etc. Furthermore, the acquisition module will be activated with various types of sensor such as cameras and measuring instruments.

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