

An Experience-Connected e-Learning System with a Personalization Mechanism for Learners' Situations and Preferences

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Abstract

This paper presents an “experience-connected” e-Learning system that facilitates users to learn practical skills of foreign language by associating knowledge and daily-life experiences. “Experience-Connected” means that the users of this system receive personalized and situation-dependent learning materials automatically. Knowledge associated to users’ daily-life has the following advantages: 1) provides opportunities to learn frequently, and 2) provides clear and practical context information about foreign language usage. The unique feature of this system is a dynamic relevance computation mechanism that retrieves learning materials according to both preference relevance and spatiotemporal relevance. Users of this system obtain appropriate learning materials, without manual and time-consuming search processes. This paper proves the feasibility of the system by showing the actual system implementation that automatically broadcasts the media-data of foreign language learning materials to smart-phones.

KEYWORDS

mobile technology, experiential learning, foreign language learning, correlation calculation

1. Introduction

In recent years, new educational environments with day-to-day knowledge acquisition methods are becoming possible to be realized by combining mobile computing devices and multimedia information resources. The global smart-phone uses are expected to be approaching to 2.5 billion units throughout 2010 to 2015, at 24% of compound annual growth by the end of that period [1]. The global wireless base transceiver station shipment is also growing at 32.3% in 2010 [2]. According to those

growths, mobile data traffic is becoming a majority of total Internet traffic. Traffic rate from Wi-Fi and mobile devices is expected to be 54% of IP traffic in 2015, while that rate in 2010 is 37% [3]. As the various knowledge acquisition methods are changing into day-to-day procedures via mobile devices, educational environments are becoming to require involving the mobile technologies. Recently, some learning systems using mobile device have been proposed. A case-study of Mobile adaptive CALL (MAC) has been shown by Uther *et al.* [4]. A technological support for experiential learning [5] with personal digital assistants (PDAs) has been implemented by Lai *et al.* [6]. They have claimed that the mobile technologies are effective for the education through learners’ experiences. Associating daily experiences with learning materials is effective to support learners’ practical knowledge acquisitions in the mobile educational environments. In fact, Waragai *et al.* [7] have introduced “the ubiquitous experience-connected learning system”, which automatically provides learners with learning materials according to their daily contexts, in the foreign language education field (concretely German curriculum) in SFC (Shonan Fujisawa Campus) of Keio University.

Learners’ preferences and spatiotemporal situations are important factors in order to realize mobile educational environments for experiential learning. Generally, learners’ preferences determine learners’ dynamic intentions on daily life. Learners’ spatiotemporal situations determine learners’ dynamic situations. In our study, these dynamic intentions and situations are defined as learners’ experiences. Though associating learners’ experiences with learning materials is effective for mobile learning, those associations are difficult to preliminarily define. The number of the combinations between experiences and learning materials is beyond the manageable quantity. In addition, if the users’ preferences are considered, it is necessary to

evaluate the appropriate combinations related to the preferences. Therefore, a dynamic association method reflecting user’s situations and intentions is needed for actual system implementations.

This paper presents an “experience-connected” e-Learning system that facilitates users to learn practical skills of foreign language by dynamically associating knowledge and experiences. “Experience-connected” means that the users of this system receive personalized and situation-dependent learning materials automatically. For example, a user learning Spanish in the bookstore can get the Spanish sentences which are frequently used there (the way to pay the money or ask about the location of books) or Spanish keywords which he/she is interested in. The learners can practice their learning languages with their experience-connected learning materials. Knowledge associated to users’ daily-life has the following advantages: 1) provides opportunities to learn frequently, and 2) provides clear and practical context information about foreign language usage.

The feature of the system is that it dynamically calculates correlations between learners’ experiences and the learning materials in the viewpoints of the learners’ preferences and the curricular adequacy. These aspects are the main factors related to learners’ motivation. Novices often have difficulties for keeping their motivation in daily-life learning because retrieving adequate learning materials is a time-consuming and difficult task for them. In order to select adequate materials for their continuing learning, the system provides new functions using the semantic associative search method [8]. The system defines the metadata of the learning materials as vector metadata on the learning-material feature space. The system constructs hybrid feature space that combines preference-based features and curricular-based features. The system also defines the metadata of experiences as vector metadata on the experience feature space. Then, the system creates the matrix for vector transform from the experience feature space into the learning-material feature space as to learners’ personalities. Finally, the system calculates the correlation between learners’ experience metadata and the learning material metadata.

The advantages of the system are as follows: the learners can 1) practice using the learning materials which are not preliminarily connected with the experiences, 2) learn appropriate learning materials by interesting and preferred material selection and 3) develop their abilities with the advanced learning materials for them.

2. Experience-Connected e-Learning System Design

A unique feature of the experience-connected e-Learning system is to calculate the correlation between

the metadata of learning materials and the metadata of the learners’ daily experiences by defining the relevance between the meanings of metadata. The system describes the relevance as a matrix named as knowledge-experience transmission matrix according to learners’ preferences and educational effects of learning materials. Figure 1 shows the architecture of the system and the how it provides the learning materials for the learners.

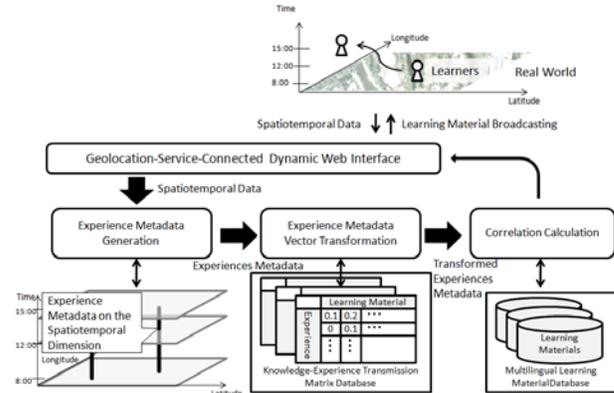


Figure 1. System Architecture: The system transforms a generated learners' experience metadata to the dimension of learning materials and computes the correlation between the experience metadata and learning material metadata

The data flow of the process of providing learning materials is as follows: 1) a learners' location data is sent from their mobile devices with the GPS location service, 2) an experience metadata is generated according to the location data and a current time, 3) the experience metadata is transformed to the dimension of the learning materials with the knowledge-experience transmission matrix, 4) the correlation of each learning material with the experience metadata is calculated, and the learning materials with high-correlation is provided for the learners.

2.1. Data Structure

This section defines the 3 types of data structures to associate the learners’ experiences with the learning materials: 1) the knowledge-experience transmission matrix, 2) the metadata of the learners’ experiences, and 3) the metadata of the learning materials.

2.1.1. Knowledge-Experience Transmission Matrix Definition

The knowledge-experience transmission matrix is the matrix which aims to transmit the metadata of the learners' experiences to the dimension of the learning material metadata with describing relationships between the feature set of the experience metadata-vectors and

the feature set of the learning material metadata-vectors. Figure 2 shows the structure of the matrix. The characteristic point of the matrix is that the feature sets of the experience metadata and the learning material metadata consist of a combination of a curricular feature set with a preference-dependent feature set. The curricular feature set aims to keep the educational effects, and the preference-dependent feature set aims to reflect the learners' interests. The system has the same number of matrices as the combination of the learners and the educational curricula to personalize the correlation calculation. The dimension of learning material metadata of each matrix depends on the target learning materials in order to manage any kind of curriculum. The dimension of experience metadata is common to all matrices, so that the system require the only one function to create experience metadata. The part of matrices' elements corresponding to one or more preference-dependent feature sets (preference elements) are variable according to each individual learner's preferences, so that the system can provide the learners with the learning materials proper to their preferences. The other part of the elements corresponding to the both curricular feature sets of experience metadata and learning material metadata (curricular elements) are constant in order to keep off the bias of learning material selection with excessive personalization and maintain the learning materials' educational effects.

		Feature Set of The Learning Material Metadata-Vectors					
		Curricular Feature Set			Preference-Dependent Feature Set		
Feature Set of The Experience Metadata-Vectors	Curricular Feature Set	0.1	0.2	...	0.1	0.05	...
		0	0.1	...	Variable Preference Elements		
	⋮	⋮	Constant Curricular Elements				
	⋮	⋮	⋮				
	Preference-Dependent Feature Set	0.2	Variable Preference Elements				
0							
		⋮					

Figure 2. Knowledge-Experience Transmission Matrix: It describes relationships between the feature set of the experience metadata-vectors and the feature set of the learning material metadata-vectors.

The system describes the experience metadata as the $n + m$ dimension vectors with n -dimension curricular feature set and m -dimension preference-dependent feature set. Table 1 shows an example of the preference-dependent feature set and curricular feature set of the experience metadata. This paper proposes a temporal 201-dimension feature set consisting of 112-dimension curricular feature set and 89-dimension preference-dependent feature set for the prototype system implementation and experiments. In the prototype system, the words of the curricular feature set are

selected from a guidebook of Japanese dialogue in everyday life for English speakers [9], because they need to be based on educational knowledge. The words of the preference-dependent feature set of the system are chosen from the preference attribute categories of the web advertising service (Google AdSense¹).

2.1.2. Metadata of The Learners' Experiences Definition

The metadata of the learners' experiences are the feature dimension vectors describing the learners' daily experiences with n -dimension curricular feature set and m -dimension preference-dependent feature set. In order to generate the experience metadata of the learners' experiences on the real world, the system preliminarily has the basic experience metadata associated with the 3-dimensional (latitude, longitude, and time of day) vectors. The time of day means a temporal interval when learners are maintaining a certain experience. We describe the time of day by start-time and end-time of an experience. Each vector element expresses the relevance of the experience to the feature word of the element by the real number from 0 to 1.

2.1.3. Metadata of The Learning Materials Definition

The metadata of the learning materials are also the feature dimension vectors with n -dimension curricular feature set and m -dimension preference-dependent feature set describing the characteristics of the individual learning material. Since specific words of the feature sets and the number of them depend on the data source of each educational curriculum, the system has the transmission matrix for every data source. The system performs multilingual material broadcasting from various language sources by selecting the appropriate transmission matrix.

2.2. Main Functions of the System

The system retrieves the experience-connected learning materials and provides the learners with them by generating learners' experience metadata and calculating the correlations between the experience metadata and learning material metadata. The system has 3 main functions for the retrieval and provision as follows: function 1) experience metadata generation according to the learners' location and current time, function 2) experience metadata vector transmission, and function 3) correlation calculation between the learners' experience and the learning materials.

¹ <http://www.google.com/ads/preferences/>

Table 1. Example words of the feature set to explain the learners' experiences: They consist of a combination of the curricular feature set, which aims to keep the educational effects, and the preference-dependent feature set, which aims to reflect the learners' interests.

Curricular Feature Set	Preference-dependent Feature Set
Greetings/Making friends, Numbers, Time, Morning, Afternoon, Evening, Night, Typical day, Holidays, Post office, Bank, Cleaning shop, Tailor, Beauty shop, Barber, Department store, Travel agent, Bike shop, Gas station, DVD rental store, Library, Internet cafe, Convenience store, Repairs, Car, Bus, Boat, Road, Airplane, Train, Station, Signal, Signs, House, Condominium, Apartment, Dormitory, Garbage, Grocery, Green grocer, Fish monger, Bucher, Bakery, Liquor Store, Stationary store, Bookstore, pharmacy, Boutique, Daily goods, cooking, Women's clothing, Women's Accessories, Men's items, Restaurant, Karaoke, Movies, Amusement park, aquarium, Mountains, Beach, Concert, Walking, Baseball, Soccer, Volleyball, Basketball, Rugby, billiards, Darts, Bicycling, Swimming pool, Park, Traveling, Eat out, Party, Gym, Pets, Temple, Shrine, Literature, Weddings, Funerals, Horoscopes, Personality, Childbirth, Childcare, Playing with children, Kindergarten, Day care, Things to bring, school subjects, Events/Health check-ups, Junior high school, High school, Universities, Talking with the teacher, Words to use at work, Service industry, Office/Telephone transactions, Public office, Alien Registration, Health/Pension/Administration service, Fees for public services, Disaster, Police, Hospital, Solving problems, Polite language, Descriptive words, Verbs, history, Living things (112 feature words) [9]	Online Media, Fun & Trivia, Comics & Animation, TV & Video, Visual Art & Design, Humor, Movies, Acting & Theater, Celebrities & Entertainment News, Music & Audio, Games, Consumer Electronics, Computers & Electronics, Toys, Gifts & Special Event Items, Antiques & Collectibles, Entertainment Media, Auctions, Luxury Goods, Apparel, Mass Merchants & Department Stores, Sports Coaching & Training, Sporting Goods, Individual Sports, Team Sports, Combat Sports, Gossip & Tabloid News, Weather, Politics, Newspapers, Candy & Sweets, Non-Alcoholic Beverages, Cooking & Recipes, Culinary Training, Grocery & Food Retailers, Restaurants, Pets & Animals, Animal Products & Services, Wildlife, Cottage, Women's Interests, Family & Relationships, Men's Interests, Social Issues & Advocacy, Social Sciences, Work & Labor Issues, Education, Home Furnishings, Gardening & Landscaping, Kitchen & Dining, Swimming Pools & Spas, Homemaking & Interior Decor, Bed & Bath, Yard & Patio, Home Appliances, Asia, Africa, Oceania, Europe, Latin America, Middle East, North America, Polar Regions, Travel, Bus & Rail, Hotels & Accommodations, Car Rental & Taxi Services, Travel Guides & Travelogues, Luggage & Travel Accessories, Travel Agencies & Services, Air Travel, Cruises & Charters, Tourist Destinations, Books & Literature, Law & Government, Finance, Science, Beauty & Fitness, Autos & Vehicles, Crafts, Outdoors, Radio Control & Modeling, Carnival & Mardi Gras, Halloween & October st, Valentine's Day, Thanksgiving, New Year's, Birthdays & Name Days, Weddings (89 feature words) from Google AdSense (1

2.2.1. Function 1) Experience Metadata Generation According to the Learners' Location and Current Time

The system generates the experience metadata representing the learners' current activity in daily life by analyzing learners' dynamic contexts (the location and the current time sensed by the Smartphone) and synthesizing prepared experience metadata vectors. We define the metadata generation function, $f_{context}$, as follows.

$$f_{context}(x, y, t, p, k) \rightarrow V \quad (1)$$

$$V = \left\{ \sum_{j=1}^k M'_{[1,j]}, \sum_{j=1}^k M'_{[2,j]}, \dots, \sum_{j=1}^k M'_{[201,j]} \right\} \quad (2)$$

$$M' = [M_1, M_2, \dots, M_k]^T \left| \begin{array}{l} \sqrt{(X(M_i) - x)^2 + (Y(M_i) - y)^2} < p \wedge \\ T_{start}(M_i) < t < T_{end}(M_i) \end{array} \right. \quad (3)$$

where V is the generated experience metadata and M' is the matrix composed the k numbers of the prepared experience metadata selected from M , which is the set of the prepared experience metadata associated with the spatiotemporal information. The selection logic of the prepared experience metadata is that the Euclidean distance between the location of the metadata M_i ($X(M_i)$, $Y(M_i)$) and the location of the learner (x , y) is less than p and current time t is during the time-zone of M_i (from $T_{start}(M_i)$ to $T_{end}(M_i)$).

2.2.2. Function 2) Experience Metadata Vector Transmission

In order to calculate the correlation between the learners' experiences and the learning materials, the

system transforms the generated experience vector metadata into the dimension of learning material metadata with the knowledge-experience transmission matrix. Since the experience metadata dimension of the prototype system shown in this paper is 201-dimension, the system transforms the experience vector into the l -dimension of the learning materials with an $l \times 201$ matrix by linear transformations.

2.2.3. Function 3) Correlation Calculation between the Learners' Experience and the Learning Materials

We define the correlation between experiences and learning materials as a semantic distance between the experience metadata and learning material metadata. The system calculates the semantic distance by cosine similarity of the vector metadata, ranks the learning materials in order of the cosine similarity and provides them for the learners.

3. System Implementation

We implemented the web application of proposed e-learning system architecture as the prototype system. The prototype system runs on the web browsers of the Smartphone and personal computers for the satisfaction of learners' various requirements on their daily life (Figure 3).

The learning material data which the system manages are the multimedia multilingual learning materials, specifically the vocabulary and grammar e-learning materials used in the Spanish classes of Keio University² and news movies and scripts broadcasted by AFP³. We

² <http://estudio.sfc.keio.ac.jp/>

³ <http://www.afpwaa.com/>

defined the keywords of the Spanish class curriculum as the feature words of learning material metadata and their metadata values manually for the experiments with the prototype system.

The system dynamically provides the learning materials according to the learners' dynamic contexts of their location and the time of day. For this dynamic provision, the system has a location-driven web interface with Geolocation API and Ajax functions. The interface senses learners' location by Geolocation API and automatically updates the location information as to learners' movements. The system revises the ranking of the learning materials according to the updated location information with Ajax functions, which displays new data with replacing a part of data on the existing pages. The advantage of the location-driven web interface is that the learners are able to utilize the web application with well operability as if by a native application.



Figure 3. The prototype-system screenshot of a smart-phone web application in the example of searching around the station

4. Experimentations

In order to evaluate the feasibility and effectiveness of the proposed correlation calculation model, we conducted two experiments with the prototype system as follows: 1) effectiveness evaluation of the learning material broadcasting with the knowledge-experience transmission matrix, 2) feasibility evaluation of the matrix personalization for learners' preferences.

4.1. Experiment 1) Effectiveness evaluation of the learning material broadcasting with the knowledge-experience transmission matrix

The aim of the experiment 1 is to evaluate the effectiveness of the knowledge-experience transmission matrix for broadcasting the learning materials satisfying both of learners' curricular needs and their preferences. We prepared the ranking results by correlation calculation using 3 patterns of the knowledge-experience transmission matrix: 1) the curricular element part, 2) the preference element part and 3) the whole part of the matrix. Then, we calculate the precision, which is the fraction of broadcasted materials which has been manually defined as relevant.

4.1.1. Experimental data

For the evaluation of broadcasting according to the learners' varied contexts, we set up 16 different context patterns (the combination of 2 curricular levels, 2 preferences, and 4 experiences), and executed the material broadcasting with 3 parts of the knowledge-experience transmission matrix for each context pattern.

4.1.2. Experimental result

The result of the experiment 1 shows that the precision of the learning material ranking by using 3) the whole knowledge-experience transmission matrix is generally higher than that of the ranking by using 1) the curricular element part or 2) the preference element part of the matrix. Figure 4 shows the averaged precision graphs of each matrix usage pattern for each learner. For all ranking results, the whole matrix used precision is higher than at least one of the two precision of the curricular element matrix and the preference element matrix. Therefore, proposed learning material broadcasting algorithm using the knowledge-experience transmission matrix will be effective for experience-connected learning material broadcasting according to learners' both aspects of curricular needs and preferences.

4.2. Experiment 2) Feasibility evaluation of the matrix personalization for learners' preferences

The aim of the experiment 2 is to evaluate the feasibility of the broadcasted material ranking adjustment by matrix personalization for learners' preferences. Matrix personalization is to revise the values of preference elements of the learners' matrices to the value appropriate to their preferential characteristics. In the prototype system experiment, we implemented the personalization by manual revising of the values. In order to show the proof of the ranking adjustment by the personalization, we compared the precisions of the material ranking which the system calculated after the personalization with the 3 parts of the matrix to the former precisions.

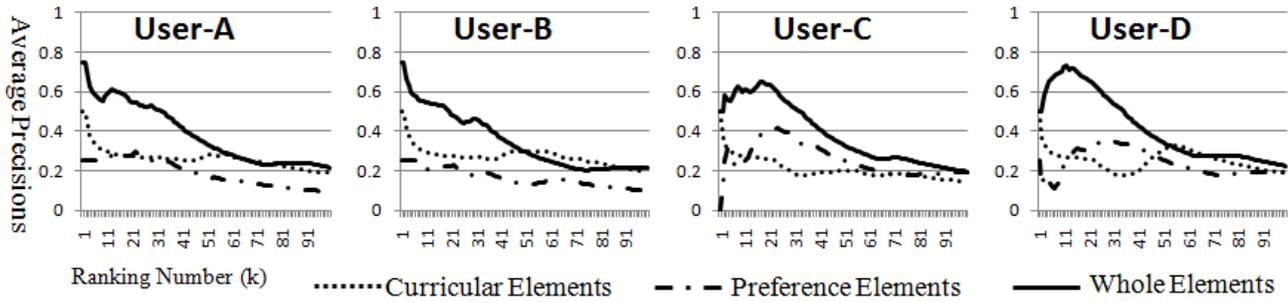


Figure 4. The average-precision graphs of each matrix usage pattern for each learner

4.2.1. Experimental data

To make the difference of the precisions emphasized, the experimental data of experiment 2 are the part of the data of experiment 1 which indicated relatively lower precisions. In the detail result of experiment 1, the case where user-B, who is in the basic course and likes gardening, takes the material ranking in the park is the least precision case, because the basic curriculum may include few leaning materials strongly connected with the gardening and almost all of the answer materials are mildly relevant to it.

4.2.2. Experimental result

The experimental result shows that the personalization of preference elements improved the precisions of the ranking with the preference element part of the matrix and accordingly the precisions of the ranking with the whole matrix (Figure 5).

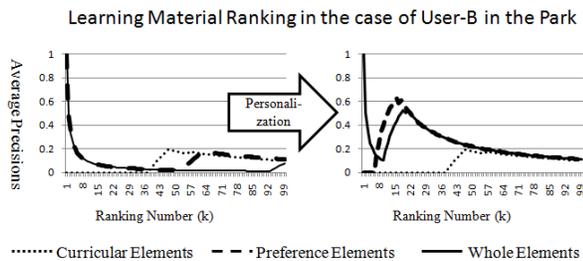


Figure 5. The difference of the average precisions after the personalization of the transmission matrix

5. Conclusion

This paper has presented the implementation method of the experience-connected e-learning system for associating learning materials with learners’ daily experiences by calculating correlations between learners’ experiences and learning materials. The experiments with the system have shown the effectiveness and the feasibility of the proposed system. As the future study, we will implement an actual application environment for real learners and more kinds of learning materials with the operations of matrix creation and personalization. By

experimental studies with our system, we will evaluate the feature set of the vector metadata and experience-connected learning styles.

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