Design of an Age-friendly E-commerce System

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Abstract

With the explosive increasing of emerging mobile and online tools and services that dramatically change people's daily living activities and the growing population of aging people, it is urgent to develop age-friendly systems that allow the elderly to quickly learn and enjoy the fast-changing world. In this paper, we focus on one of the most important online activities, i.e. online shopping, and proposed a design of an age-friendly E-commerce system. Specifically, we present our ideas on choosing from state-of-the-art AI technologies for the development of functional modules that may be helpful to the elderly during online shopping and illustrate our system integration methods that starting guideline for practitioners. Future work of this study will focus on user studies that help us to improve the system in terms of usability and user experience for the elderly.

Keyword: elderly, age-friendly, e-commerce system

I. Introduction

Stepping into the era of digital life, people are enjoying the convenience and efficiency of mobile and online interactions, and especially, and are becoming used to mobile applications and WIFI with daily living activities. However, it has been widely recognized [1] that currently such technologies mostly favor the younger generation while the elderly people may not take the benefits fully mainly because of the digital gap. As summarized in [1], the first challenge towards that is the unfamiliarity

to computer - the elderly has been found to require nearly 1.5 times of the time to complete the same task using the internet than the young people, and be more likely to give up online interactions. The second challenge is the decline in the physical and cognitive functions of aging people. Especially, considering that the world population is aging at an unprecedented rate, where by 2050, the number of persons aged 65 years and above will reach 1.6 billion [2], it is the time to develop age-friendly technologies to guarantee the healthy and active living of the elderly.

E-commerce has become one of the most important IT technologies that benefit people's daily living in the way of allowing customers to directly buy goods or services from a seller over the Internet using a web browser. Because of its convenience, it has been reshaping the attitude and behavior of customers for purchasing products. However, the senior population shows less interest in shopping online. This is because that most of the current E-commerce websites do not fully cover the requirements of the elderly. Some of these websites are either not clear or intuitive enough, inevitably bringing difficulties to the elderly suffering from age-related impairments or unfamiliar with computer.

This paper presents the design towards an age-friendly e-commerce system that is integrated with six Artificial Intelligence (AI) technologies including multimodal search, speech recognition, voice conversion, reputation evaluation, word embedding, and collaborating filtering. Five key functions are implemented including:

1) **Multimodal Product Search** enables easy online shop-ping interactions for the elderly by providing flexible search modalities - search for products of interests using an image, or a short description, voice, or a combination of these;
2) **Personalized Speech Feedback** tells the search results to the elderly with personalized voices to reduce their time watching screens, and allows them to create or customize the voices for the most comfortable ones;

3) **Keyword Recommendation** provides diverse search options to the elderly to facilitate the browsing of unfamiliar products by recommending keywords of relevant products according to their text query;
4) **Product Reputation Evaluation** helps the elderly filter products of low quality by evaluating the reputation of products according to customer ratings;
5) **Personalized Product Recommendation** recommends products based on the elderly's interests by analyzing their profiles and past online shopping histories

In the remainder of paper, we will first illustrate the proposed age-friendly E-commerce system, and subsequently describe each of the five functions respectively.

II. OVERVIEW OF AGE-FRIENDLY E-COMMERCE SYSTEM

A. General architecture

The architecture of the proposed age-friendly E-commerce system is shown in Figure 1. As observed, the system architecture of the integrated E-commerce system includes three main components:

- Client side: provides web-based interfaces for customer interactions with the five key functional modules dis-cussed above;
- Business layer: includes technologies developed to sup-port the five functional modules. Algorithms implemented using Python SciPy Library guarantee the service efficiency;
- Server side: using MariaDB as the relational based database management system to store relevant E-commerce data required by client side and business layer. Using Django web framework's ORM (Object Relational Mapping) as data access layer for efficient data communication between the client and business layer.

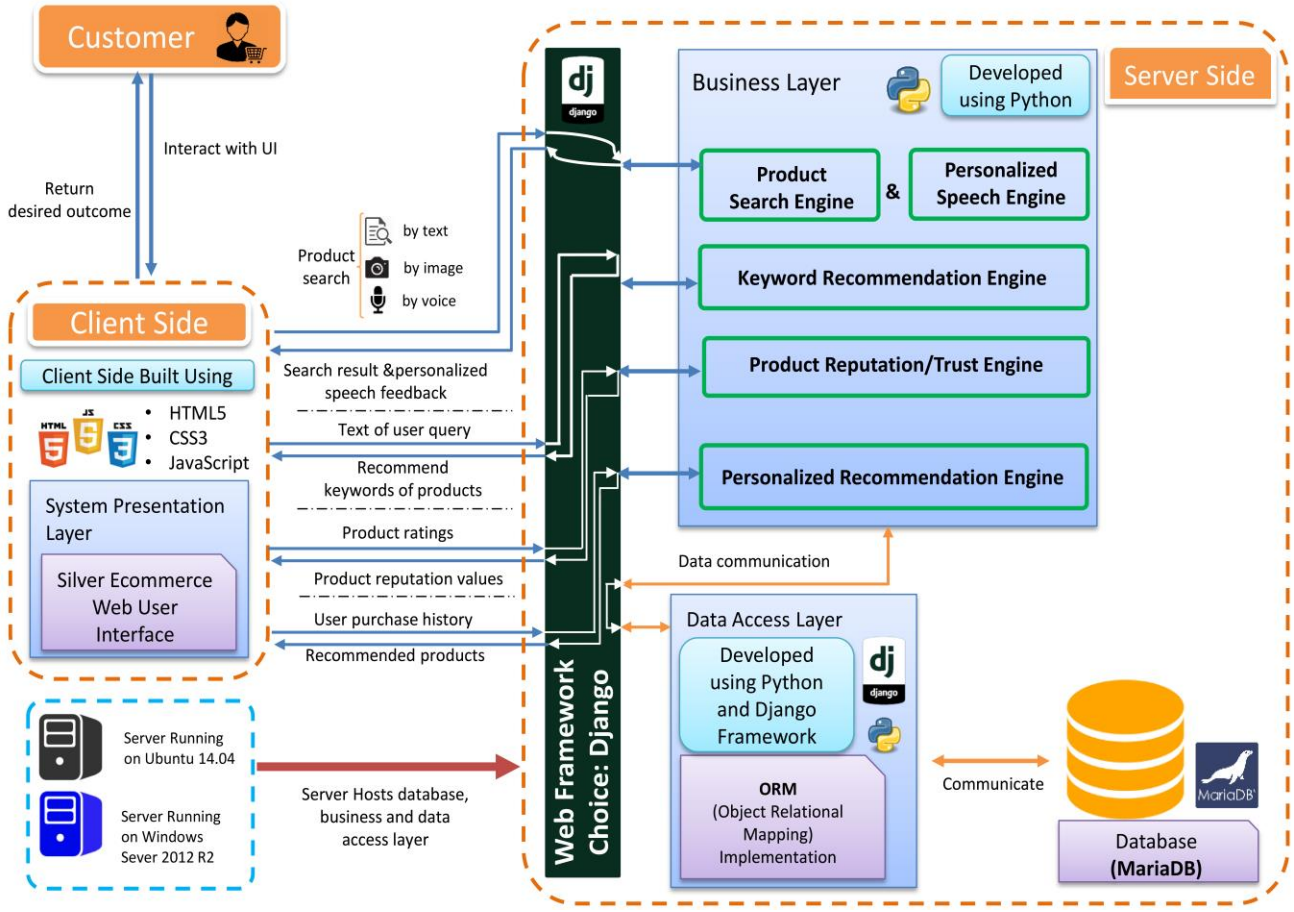

Figure 1 System architecture for age-friendly E-commerce system.

A web interface communicates the client/user with servers that contains: products indexing, product search, keyword recommendation, products recommendation, speech recognition, speech synthesis. The data communication between client and server is developed using Python Django web framework.

The flow of system communications is described as follows. When a registered user accesses the web application, the server will send the recommended products based on the user purchase history. User can also provide the search query via text, image or speech. These requests will be sent to the back-end server for processing using the appropriate algorithms developed in our age-friendly E-commerce system. After the request is received, the server first converts the speech requests in audio file format into text. Then the server extracts the text and image information to search products in database. When the search process has been completed, the server sends the search results with

products reputation, speech feedback and the recommended keywords, related to the search query, to the client/user.

B. Implementation details

Web application are applications that are created on request to serve dynamic web contents based on the interactions between the client/user and web servers. [3]

The front-end of the web application is implemented in the combination of HTML5, CSS3 and JavaScript. It is a web interface communicates the client/user with servers to input searching queries and display results.

The back-end of the web application are hosted in two different servers, one is running on Ubuntu 14.04 where all the five functional modules, data access layers and web services are deployed here; the other server is running on Windows Server 2012 R2 where the speech related service (e.g. speech synthesis, speech conversion) is deployed. Python is used as a glue language to bridge the communication between the Ubuntu server and Windows server by using the TCP/IP protocol.

Python is a programming language which has the strength of flexibility, scalability and excellent performance. Unlike traditional programming language in web development do-main, Python is fast in prototyping and make it suitable to try out new ideas. Considering algorithms used to support the five functional modules are mainly implemented in Python. Based on those considerations, Python programming language is chosen as the programming language for back-end service development.

To ensure the maintainability of the web application development, Django web framework is chosen to assist to achieve clean, pragmatic design of the E-commerce system. All tasks involving any significant computational load (i.e. products indexing, product search, keyword recommendation, products recommendation, speech recognition, speech synthesis, etc.) run on the server side.

The interaction between the client and the server applications is based on the HTTP and HTTPS protocol. Communications between client and the speech server (server running on Windows Server 2012 Standard) is based on TCP/IP protocol, where the client/user send input(text or audio) to the server, which in turn process the request and send back encoded audio signal in JSON format.

C. *AI Powered Algorithmic Engines*

In the following parts, we illustrate various toolkits and algorithms used in our system to realize the functions indicated in the business layer, i.e. the product search, the personalized speech feedback, the keyword recommendation, the product reputation, and the personalized recommendation.

1) Multimodal product search engine: Multimodal product search engine aims at providing users flexible ways to search for their desired products in the E-commerce platform. It helps to improve the diversity and accuracy of search engine by enabling multimodal queries and can perform online update of the database.

   Thee core algorithms of the image searching and speech searching scripts are based on the online multimodal co-indexing adaptive resonance theory (OMC-ART) [4] and Bing Voice Recognition API [5].

   Specifically, OMC-ART is developed from a series of ART-inspired unsupervised learning algorithms [6, 7, 8, 9, 10, 11]. Given a raw product dataset with product photos and textual description, without additional resources, this algorithm automatically extracts the visual and textual features of products and builds a two-layer index hierarchy, of which the bottom layer contains clusters of similar products while the upper layer contains generalized characteristics of products in the same cluster, represented by cluster weights. Thus, products are co-indexed by the key visual and textual features in this hierarchy, which serves as the product index base and enables image- and/or text-based search.

2) Personalized speech feedback: The personalized speech feedback engine is used to generate the customized speech based on the search results. To make the engine more flexible, both text-to-speech (TTS) and voice conversion techniques are used. In our implementation, IVONA 1 TTS engine is firstly used to generate the speech based on the search results. Then, voice conversion technique is used to generate personalized speech feedback. To achieve a high-performance VC system, a system fusion framework [12] is used. Two state-of-the-art methods are chosen as the candidate systems, including GMM with GV enhancement [13] as the GMM-based approaches, and sparse representation-based FW [14] as the FW-based approaches. More details can be found in [12].

3) Product Reputation: The Product reputation engine aims to improve the searching accuracy and filter out the irrelevant products. It is responsible for calculating the reputation and re-ranking the products searching results based on the products quality. The reputation is calculated using the fuzzy-logic reputation engine to give a final score of the product [15], which is achieved by evaluating the rating information of the buyers history transactions and simultaneously countering the negative effects of various types of unfair ratings. Specifically, for each rating, Product Reputation Model (PRM) considers three aspects of information: 1) temporal information, i.e. the date and time when the rating is given; 2) similarity between the ratings given by the provider and other buyers; and 3) expertise of the rating provider. Based on such information, fuzzy logic techniques are employed to compute a weight, i.e. importance score, for each rating, and the final reputation value of the product is computed as the weighted sum of all rating values.

4) Keyword recommendation: Keyword Recommendation Engine recommends keywords to users based on their textual queries to enhance user experiences. The core technology extracts the semantics of words, phrases, and even sentences and projects them into real-valued vectors so that the words having similar meanings have a short distance in the feature

space. It helps to provide diverse options for a user to browse the products and do recommendation even for highly complex user queries.

5) Personalized recommendation: Personalized Recommendation Engine [16] recommends products to users based on their on-line purchase history. The core technology is based on the collaborative filtering and linearly combines multiple recommendation algorithms using an adaptive weighting strategy for accurate item recommendation. Regarding the user experience perspective, this algorithm can base on the elderly's interests and recommend popular or new products that fit the elderly's preferences more efficiently. Moreover, this algorithm achieves 5% higher accuracy over existing technologies on three benchmark data sets, achieved by linearly combining multiple homogeneous component recommenders.

III. Conclusion

In this paper, we present the design of an age-friendly E-commerce system that leverages state-of-the-art AI technologies for assisting the elderly for online shopping. Specifically, we focus on the system integration methods that effectively and efficiently integrate six AI technologies in to a Python-based framework with multi-server cross-environment implementations.

We hope the proposed design can serve as a starting guideline for practitioners. Future work of this study will focus on user studies that help us to improve the system in terms of usability and improved user experience for the elderly.

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