Creating adaptive web recommendation system based on user behavior

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Abstract. The paper proposes adaptive web recommendation system based on user behavior. The proposed system uses expert system to evaluating and recommending suitable items of content. Relevant items are subsequently evaluated and filtered based on history of visited items and user’s preferred categories of items. Main parts of the proposed system are presented and described. The proposed recommendation system is verified on specific example.

1. Introduction

Nowadays, there are a lot of web pages, web applications and web systems which contains various types of content (text, images, videos, etc.). Typically, web pages provide the same content for all users (online news portals, web portals, web magazines). Some of them adapt the content based on user behavior and user preferences (for instance Youtube, Booking.com, Facebook, etc.).

Adaptation of the content based on user behavior is a good benefit for user, because specific web page recommends suitable items of content or content categories, which are preferred by user. Currently, there are few approaches for adaptive web pages, which can adapt the content.

The first approach is a rule-based system for adapt the web page content based on decision-making rules. The approach is more described [1], [2]. Another approach is a content-filtering system which filters the content of web page based on history of visited items [3]. Another approach is a collaborative filtering system which presumes that items preferred by user in past will be preferred also in future [4], [5], [6].

Another approach performs a prediction of the subsequent appropriate content items [7]. Current opportunities and challenges for adaptive web services are described in [8]. In this paper, we focus on web pages which contains products, typically e-shops.

2. Proposed approach

We propose an adaptive web recommendation system based on user behavior. The proposed system uses expert system to evaluating and recommending suitable items of content.

The proposed system recommends suitable items in two main situations, during first visit of user on web page and during the user’s activity at the web page (staying on the web page).

In the first situation, the system uses expert system to evaluate items relevancy based on item properties (importance of item, frequency of visiting the item by other users, frequency of selling the item by users). Evaluated items are then ordered by their relevancy and shown to users. This output decreases the effect called “cold start”. Cold start is the main problem of current adaptive web systems.
and represents situation of no input data to these systems after first visit the web page by user [8]. Adaptive systems has no information about user behavior (history of visited items of content, time spent on specific web page, etc.), so it is difficult to recommend suitable items and adapt the content.

In the second situation, the system stores information about user behavior (history of visited items, preferred items, preferred categories of items, etc.) and adapts the content based on these data and items relevancy evaluated by expert system.

Main parts of the proposed approach will be described in the following sections.

2.1. Loading information about user

In the first step, information about user are loaded and prepared for subsequent steps. There are a lot of information about user which can be recognized and loaded during visit on the web page. Here are examples:

- Gender (male, female)
- Age
- Operating system type
- Browser type
- Device type (mobile phone, tablet, phablet, notebook, PC, etc.)
- History of visited pages on website

2.2. Creating the expert system

In the next step, an expert system is created. The knowledge base of expert system consists of IF-THEN rules. The main role of the expert system is to evaluate and recommend relevant content items to the user. After first visit of the web page, products will be evaluated and ordered by their relevancy. This step is important to decrease the effect of “cold start”.

IF-THEN rules of expert systems consists of three input linguistic variables and one output linguistic variable.

Input linguistic variables are:

- IMP - importance of item in a category, administrator of we page decides which items are more (favorite items, bestsellers) or less important, possible values are:
  - low
  - medium
  - high
- VISIT - level of visiting the item – represents how many people visit the item, possible values are:
  - low
  - medium
  - high
- SALE - sales level of the item – represents frequency of selling the item, possible values are:
  - low
  - medium
  - high

Output linguistic variable is:

- RELEVANCY – level of item relevancy, possible values are:
  - very low
  - low
  - medium
  - high
  - very high
Examples of IF-THEN rules of knowledge base are shown below:

IF (IMP IS LOW) AND  
(VISIT IS LOW) AND  
(SALE IS LOW) THEN  
(RELEVANCY IS VERY LOW)

IF (IMP IS MEDIUM) AND  
(VISIT IS LOW) AND  
(SALE IS HIGH) THEN  
(RELEVANCY IS MEDIUM)

IF (IMP IS HIGH) AND  
(VISIT IS MEDIUM) AND  
(SALE IS MEDIUM) THEN  
(RELEVANCY IS HIGH)

The expert system is created in LFLC (Linguistic Fuzzy Logic Controller) tool [9]. This tool enables to create a knowledge base of an expert system and also performs the process of the decision making together with the specific output, which is possible to use in the proposed system.

2.3. Evaluating items relevancy

In this step, the items of content are evaluated by expert system. The relevancy of each item is evaluated based on properties of items and knowledge base of the expert system. Next, the items are ordered by their relevancy and recommended to the user. There are many ways how to show these items to the user. One of them is to create content block called “Relevant items” and put ordered items to this block. Evaluated items are displayed at the first and every subsequent visit of the web page.

Process of evaluating items relevancy by expert system is shown in Fig. 1.

![Figure 1. Process of evaluating items relevancy by expert system](image-url)
2.4. Adapting the content and recommending the most relevant items

In this step, the content of the web page is adapted based on other user activity on the web. Based on visited items the system recommends the most relevant items based on these rules:

- Relevant items (items with highest relevancy evaluated by expert system) with the same categories as categories of items visited by user
- Relevant items with similar price as price of items visited by user

Based on these rules the system automatically selects the most relevant items and show them to the user ordered by their relevancy evaluated by expert system.

Process of recommendation of the most relevant items is visually shown in Fig. 2.

![Diagram showing the process of recommendation of the most relevant items](image)

**Figure 2.** Process of recommendation of the most relevant items

3. Verification

For verification the selected products of real e-shop were chosen. Information loaded by user are:

- Age
- History of visited pages on website

List of items for verification is shown in Table 1:

| Num | Product name                  | Price (USD) | Category          | Preferred age |
|-----|-------------------------------|-------------|-------------------|---------------|
| 1   | The Miracle of Dunkirk        | 9.99        | History           | adults        |
| 2   | Munich 1919: Diary of revolution | 22.92     | History           | adults        |
| 3   | Killing England               | 20.98       | History           | adults        |
| 4   | The color of law              | 19.00       | History           | adults        |
| 5   | The art of war                | 3.99        | History           | adults        |
| 6   | A man called Ove              | 9.60        | Literature & Fiction | adults        |
| 7   | The secret she keeps          | 20.95       | Literature & Fiction | adults        |
| 8   | A gentleman in Moscow         | 16.32       | Literature & Fiction | adults        |
| 9   | The land of stories           | 13.11       | Children’s books  | children      |
| 10  | The wonderful Things you      | 11.13       | Children’s books  | children      |
Properties of products for evaluating by expert system with evaluated relevancy are shown in Table 2:

| Num | IMP | VISIT | SALE | RELEVANCY |
|-----|-----|-------|------|-----------|
| 3   | high| high  | high | very high |
| 6   | high| high  | medium| very high |
| 10  | high| medium| high  | very high |
| 11  | high| medium| medium| high      |
| 4   | high| medium| medium| high      |
| 14  | high| low   | high  | high      |
| 8   | medium| medium| medium| medium    |
| 13  | medium| low   | medium| medium    |
| 2   | low | medium| medium| low       |
| 7   | low | medium| medium| low       |
| 12  | low | low   | high  | low       |
| 5   | low | low   | medium| very low  |
| 9   | low | low   | low   | very low  |

Items with evaluated relevancy are ordered and shown to the user during first visit of the web page. During browsing the e-shop these information were stored:

- User is adult.
- User visits the books with category History and Literature & Fiction.
- User visits the books with average price about 20 USD.

The system adapts the content and recommends these items ordered by their relevancy:

| Num | Product name          | Price (USD) | Category               | Preferred age |
|-----|-----------------------|-------------|------------------------|---------------|
| 3   | Killing England       | 20.98       | History                | adults        |
| 4   | The color of law      | 19.00       | History                | adults        |
| 8   | A gentleman in Moscow | 16.32       | Literature & Fiction   | adults        |
| 7   | The secret she keeps  | 20.95       | Literature & Fiction   | adults        |
| 2   | Munich 1919: Diary of revolution | 22.92 | History | adults |

As we can see, the list of recommended items contains items of category History and Literature & Fiction, with similarity of price about 20 USD. Items are ordered by their relevancy.

4. Conclusion
In this paper we proposed the adaptive web recommendation system based on user behavior. The proposed system is connected to the expert system, which evaluates relevancy of content items. The
The proposed system recommends relevant items of content based on evaluation by expert system and user behavior (history of visited items, preferred category). Future work will focus on verification the proposed system on other examples and web pages. It will be also useful to generalize the approach and verify it on various types of web pages.

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