# Visualization of Explanations in Recommender Systems

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***Abstract*—Explanations in recommender systems have gained an increasing importance in the last few years. It was found that explanations can help increase users' acceptance of collaborative filtering recommender systems, helping them make decisions more quickly, convincing them to buy and even developing trust as a whole. They can also help in decision support and in problem solving. While the majority of research has focused on the algorithms behind recommender systems, little emphasis was put on interface which is crucial in improving user experience especially if we know that communicating reasoning to users is considered an important aspect of assessing recommender systems. The importance of this paper is that it lies in the area of controlling the recommendation process which gained little attention so far. The focus is on the visualization of explanations in recommender systems. We will learn what modalities (E.g. text, graphs, tables, and images) can better present explanations to users, through the review of a selection of papers in the literature over the last few years. The results show that explanations with simple graphs and descriptions can better present explanations (meaning that complex graphical interfaces can confuse users). The rest of this paper is organized as follows: the next section gives an introduction to explanations in recommender systems. Then, we talk about the relationship between visualization of explanations and other disciplines such as human computer interaction and decision making. We then talk about the different methods of information visualization especially those used when explanations are involved. The paper ends with conclusions and perspectives for future work.**

***Index Terms*—recommender systems, explanations, information visualization, decision making, human computer interaction**

## I. Introduction

An explanation is a bit of information that serves different goals such as giving the reason for a recommendation or giving better recommendation styles in commercial transactions [1].

Explanations have proven efficiency in previous intelligent systems, especially in expert systems such as MYCIN. However, the use of explanations in RS requires the use of an approach other than the rule-based reasoning [2].

Reference [2] is the first that talk about the importance of explanations in recommender systems. Their study was followed by a number of works such as [3]-[8].

In brief, the importance that explanations give to recommender systems falls in seven domains [8]:

- Transparency: where an explanation shows how a recommendation was suggested.
- Scrutability: where users can tell if the system is wrong.
- Trust: users' trust in the system can increase when using explanations.
- Effectiveness: helping users make good decisions about what to buy, see etc.
- Persuasiveness: convincing users to try to buy.
- Efficiency: where explanations can make it faster for users to choose the right product.
- Satisfaction: means that explanations can make users more satisfied with the overall system.

However, it is hard to achieve all the seven goals within one system. It's like a tradeoff and the system designer should bear in mind the main system goal [6].

The way a recommendation is given can affect explanation and may also show how good or relevant the item is considered to be. A number of ways have been devised to offer recommendations to system users: [6]:

- Top item: where users are offered the best item.
- Top N-items: where a number of items are offered.
- Similar to top item (s): where the system shows item (s) similar to those already chosen by the user.
- Predicted ratings for all items: where a number of items are shown to the user, where each item has a rating on a specific scale.
- Structured overview: a structure showing tradeoffs between items.
- Recommender personality: the choice of the recommended item reflects a personality of the recommender system.

## II. Correlated Disciplines

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In the section, we will talk about the decision making process, from how decisions users make can be affected by the format of information presented. Also, how the visualization of explanations can be evaluated from the human computer interaction perspective.

### A. Decision Making

Decision making is the selection of a course of action from two or more alternatives in order to solve a problem or to achieve an objective.

Research on decision making systems shows that the format of the information presented can affect what decisions consumers make and that those consumers can take different decisions in different contexts [9].

The integration of recommendation technologies with a profound realization of human decision making can improve the quality of recommendation for users and the predictability of decision outcomes [9]. In a study on the effects the explanation structure has on the use of decision support system (DSS) found that long and strongly confident explanations can be more effective in acceptance of interval forecasts. Also, explanations with higher information value can be more effective in the presentation of advice to users [10].

### B. Human Computer Interaction

HCI is concerned with how people interact with computers and how computers can be developed for successful interaction with human beings.

In [11] the authors investigated how to design a useful recommender system from the human computer interaction perspective. Nineteen people involved in the study, mostly students ranged between 20 and 35 years. They were asked to evaluate three book and three movie recommender systems. Each system has its own interface characteristics (layout, navigation, color, graphics and user interaction), types of input required and information displayed with recommendations. At the interface level, results show that navigation and layout elements are what users are concerned about, since they are correlated with ease of use and usefulness of system. However, colors and graphs were not of big importance when it comes to the perceived usefulness of system.

## III. Explanation Interface

Explanation interface is the technique used mainly to explain why a specific recommendation was suggested to the user. The importance of a good explanation presentation is that it can better explain recommendations and can even push users to make further requests [7].

The explanation interface consists of three elements: explanation, presentation and interaction. Presentation incorporates the use of styles such as content-based keyword, community-based influence and collaborate filtering-based neighborhood. It also incorporates visualization techniques. Interaction element of the explanation interface consists of two parts (i) interaction with the system itself such as feedback and (ii) interaction with other users such as making conversations [12].

The presentation of the recommended item is one of the factors that may impact explanation effectiveness [13]. Friedrich and Zanker [8] consider the creation of new presentation styles as one way to increase explanation effectiveness. The importance of a good explanation presentation is that it can better explain recommendations and can even push users to make further requests [14].

Within the intelligent system domain, an explanation has three elements (i) the content (ii) the provisioning mechanism and (iii) the format of presentation. The third element concerns how an explanation is presented to users. Two formats are used for this purpose: text-based and multimedia-based. The text-based format incorporates the use of a number of sentences, with the use of natural language in order to increase transparency. The multimedia-based format incorporates the use of graphs, pictures, animations and so on. Although this type of explanation format can be expensive and harder to develop, it can promote confidence in the system [10].

## IV. Information Visualization

Human eyes can interpret a graph much faster than plain texts, as it can process many visual cues simultaneously. However, processing a chunk of text may take more effort. To visualize information incorporated in explanations, a number of visualization techniques have been used such as tables, images, diagrams, text-highlighting, color schemes, rating and animation [12]. Visualization has been used in recommender systems in both offering recommendation to users and explaining why these recommendations were given.


Figure 1. Amazon's item-item collaborative filtering recommendation [15]

Visualization techniques have been broadly used in a number of major e-commerce websites. For example in Amazon.com (Fig. 1), there is the use of techniques such as text-highlighting, five-star rating scales, images, colors, text size, tables, animation etc.

Also, in IMDb.com website(Fig. 2), the same previous techniques are being used except for the rating scale which is there a ten-star rating scale while in Last.fm website (Fig. 3), the use of tagging is very apparent.


Figure 2. Recommendations from IMDb.com [11]


Figure 3. Newsmap - a treemap visualization of news [16]

One advanced explanation interface is called "treemap". This structure contains different colors representing topic areas, square and font size are used to represent importance to user. Shades of topic color are used to represent recency [16].

In addition to the classical 2D/3D visualization techniques such as bar charts, tables, images, etc.,) there are a number of more sophisticated methods. Geometrically-transformed displays include techniques such as scatterplot matrices, projection pursuit techniques, prosection views, hyperslice and parallel coordinates. Iconic displays include little faces, needle icons, star icons, stick figure icons, color icons and TileBars. Dense pixel displays include techniques such as recursive pattern and circle segments. Stacked displays include dimensional stacking [17].

Clutter and data overload are two common problems with information visualization. Other problems are related to the size of the graph and time complexity [18].

Reference [19] conducted a study to evaluate the credibility of two live web sites on a similar topic with 2,684 participants. Comments on the design look of the website were more than the comments of the other features such as information structure, information focus and usefulness of information. Website design look includes elements of the visual design such as layout, topography, white space, images and so on [19].

In [20], the authors conducted a study consisting of seven focus groups totaling sixty seven participants to see whether users prefer the textual or the graphical presentation style. Her results show that users do not have a clear preference for text or graphics and that their opinions were divided.

### C. Textual Representation

It has been found that concise arguments are better than lengthy and detailed arguments and that those arguments should only present pertinent and cogent information [21].

When using text as a means to represent explanations, users would prefer short sentences for low-risk products while for high-risk products, users would prefer the use of more detailed sentences [5].

Reference [22] reported that users prefer category titles to be presented in a natural and conversational language. For example, the title "These notebooks have a lower price and faster processor speed, but heavier weight" is preferred to "cheaper and faster processor speed and heavier" or "they have a lower price and faster processor speed and bigger memory, but heavier weight and large display size" because, for example, the latter explanation style includes many tradeoffs.

### D. Graphical Represntation

Presentation style can be related to users' trust or system credibility. Users have shown satisfaction towards the visual design of a website with elements such as layout, typography, font size, color schemes and the presence of a photograph of the author [14].

It was found that a system having a good graphical user interface to explain the reasoning of recommended items will lead users to better trust that system [23]. Trust was found to be the most important factor that leads to better user satisfaction and user experience with the system, as people were found to return to recommender systems that are trustworthy [24].

In a study [25] conducted to evaluate how author photos and author names can affect website credibility, found that a formal photograph of an author can increase the credibility of the article displayed. On the other hand, an author's name has no significant effect on how people perceive the article.

Reference [2] is the first that investigate how visualization techniques can enhance explanations in recommender systems. They probed 21 presentation styles and found that the use of rating histogram, with the following text "The system suggests 3 stars because it has been rated by other similar users as…", can be efficient in supporting explanations in automatic collaborative filtering systems. In addition, poorly designed explanation interface can make users no more desired in following the recommendation. Their results also show that simple graphic presentation can give a better

recommendation as compared to complex graphic representation. They also found that the use of text-highlighted statements can be effective.

Ahn and Lee [26] showed that, for collaborative filtering recommendation systems, explanations with simple graphs and descriptions, showing the impressions of similar users, can perform better than other explanation styles such as graphs or descriptions only, tables, etc.

Bilgic and Moony [4] used tables in order to represent the influence style explanation and the keyword style explanation.

Reference [27] conducted a questionnaire to discover what recommendation presentation format users prefer. Two explanation methods were offered to the participants: map-based and list-based. Ten of the users, who enrolled in the questionnaire, expressed their preference towards list-based presentation. Ten other users said that they prefer the map-based explanation, while six users showed their preference towards both list-based and map-based format.

## V. Conclusions and Future Work

A good explanation interface can be related to factors such as explanation effectiveness, users' satisfaction, trust and loyalty towards the system.

The design look of the website is what visitors care much about compared to other website features such as information structure, information focus and usefulness of information and so on. However, graphs and colors are not that important when it comes to the perceived usefulness of the system.

Arguments should contain only pertinent and cogent information while tittles are preferred to be presented in a natural and conversational language. For low-risk products, users were found to prefer short sentences. However, for high-risk products, users were found to prefer long and detailed sentences. Long and strongly confident explanations can be more effective in the acceptance of interval forecasts.

In regard to what users prefer, whether textual or graphical presentation, some authors found that users did not have a clear preference and that their opinions were divided.

Map-based and list-based explanation formats were found to be equally accepted by users. A formal photograph of an author can increase the credibility of the article, while an author's name has no significant effect on how people perceive the article.

For collaborative filtering recommendation systems, explanations with simple graphs and descriptions, showing the preferences of similar users, can perform better than other explanation styles.

There are a number of future research directions we would like to explore. One direction is to understand how we can personalize the visualization of explanation based on users' profiles.

Another direction is to investigate how to compliment the different styles of explanation visualization (e.g. animations, images, text, tables, graphs, etc.) to generate one unified model where each style plays a specific role. This model can be adapted to satisfy the different business activities.

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