

Proposal of a Novel Typicality Based Collaborative Filtering Technology for Recommender Systems to Obtain Accurate Predictions

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ABSTRACT:

Collaborative filtering (CF) is an important and popular technology for recommender systems. However, current CF methods suffer from such problems as data sparsity, recommendation inaccuracy, and big-error in predictions. In this research paper, we borrow ideas of object typicality from cognitive psychology and propose a novel typicality-based collaborative filtering recommendation method named TyCo. A distinct feature of typicality-based CF is that it finds “neighbours” of users based on user typicality degrees in user groups (instead of the co-rated items of users, or common users of items, as in traditional CF). To the best of our knowledge, there has been no prior work on investigating CF recommendation by combining object typicality. TyCo outperforms many CF recommendation methods on recommendation accuracy (in terms of MAE) with an improvement of at least 6.35 percent in Movie lens data set, especially with sparse training data (9.89 percent improvement on MAE) and has lower time cost than other CF methods. Further, it can obtain more accurate predictions with less number of big-error predictions.

KEYWORDS: Classification and Regression Trees (CART); Chi Square Automatic Interaction Detection (CHAID); Collaborative filtering (CF)

INTRODUCTION

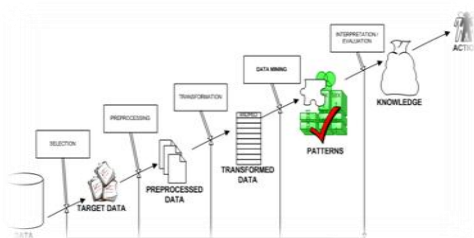


Figure 1: Structure of Data Mining

Generally, data mining (sometimes called data or knowledge discovery) is the process of analyzing data from different perspectives and summarizing it into useful information - information that can be used to increase revenue, cuts costs, or both. Data mining software is one of a number of analytical tools for analyzing data. It allows users to analyze data from many different dimensions or angles, categorize it, and summarize the relationships identified. Technically, data mining is the process of finding correlations or patterns among dozens of fields in large relational databases.

While large-scale information technology has been evolving separate transaction and analytical systems, data

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mining provides the link between the two. Data mining software analyzes relationships and patterns in stored transaction data based on open-ended user queries. Several types of analytical software are available: statistical, machine learning, and neural networks.[1] **Generally, any of four types of relationships are sought:**

- **Classes:** Stored data is used to locate data in predetermined groups. For example, a restaurant chain could mine customer purchase data to determine when customers visit and what they typically order. This information could be used to increase traffic by having daily specials.
- **Clusters:** Data items are grouped according to logical relationships or consumer preferences. For example, data can be mined to identify market segments or consumer affinities.
- **Associations:** Data can be mined to identify associations. The beer-diaper example is an example of associative mining.
- **Sequential patterns:** Data is mined to anticipate behavior patterns and trends. For example, an outdoor equipment retailer could predict the likelihood of a backpack being purchased based on a consumer's purchase of sleeping bags and hiking shoes.[2]

Data mining consists of five major elements:

- 1) Extract, transform, and load transaction data onto the data warehouse system.
- 2) Store and manage the data in a multidimensional database system.
- 3) Provide data access to business analysts and information technology professionals.
- 4) Analyze the data by application software.
- 5) Present the data in a useful format, such as a graph or table.[3]

Different levels of analysis are available:

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- **Artificial neural networks:** Non-linear predictive models that learn through training and resemble biological neural networks in structure.
 - **Genetic algorithms:** Optimization techniques that use process such as genetic combination, mutation, and natural selection in a design based on the concepts of natural evolution.
 - **Decision trees:** Tree-shaped structures that represent sets of decisions. These decisions generate rules for the classification of a dataset. Specific decision tree methods include Classification and Regression Trees (CART) and Chi Square Automatic Interaction Detection (CHAID). CART and CHAID are decision tree techniques used for classification of a dataset. They provide a set of rules that you can apply to a new (unclassified) dataset to predict which records will have a given outcome. CART segments a dataset by creating 2-way splits while CHAID segments using chi square tests to create multi-way splits. CART typically requires less data preparation than CHAID.
 - **Nearest neighbor method:** A technique that classifies each record in a dataset based on a combination of the classes of the k record(s) most similar to it in a historical dataset (where $k=1$). Sometimes called the k -nearest neighbor technique.
 - **Rule induction:** The extraction of useful if-then rules from data based on statistical significance.
 - **Data visualization:** The visual interpretation of complex relationships in multidimensional data. Graphics tools are used to illustrate data relationships.[4]
- #### Characteristics of Data Mining:
- **Large quantities of data:** The volume of data so great it has to be analyzed by automated techniques e.g. satellite information, credit card transactions etc.



- **Noisy, incomplete data:** Imprecise data is the characteristic of all data collection.
- **Complex data structure:** conventional statistical analysis not possible
- **Heterogeneous data stored in legacy systems[5]**

Benefits of Data Mining:

- 1) It's one of the most effective services that are available today. With the help of data mining, one can discover precious information about the customers and their behavior for a specific set of products and evaluate and analyze, store, mine and load data related to them
- 2) An analytical CRM model and strategic business related decisions can be made with the help of data mining as it helps in providing a complete synopsis of customers
- 3) An endless number of organizations have installed data mining projects and it has helped them see their own companies make an unprecedented improvement in their marketing strategies (Campaigns)
- 4) Data mining is generally used by organizations with a solid customer focus. For its flexible nature as far as applicability is concerned is being used vehemently in applications to foresee crucial data including industry analysis and consumer buying behaviors
- 5) Fast paced and prompt access to data along with economic processing techniques have made data mining one of the most suitable services that a company seek[6]

Advantages of Data Mining:

1. Marketing / Retail:

Data mining helps marketing companies build models based on historical data to predict who will respond to the new marketing campaigns such as direct mail, online marketing campaign...etc. Through the results, marketers will have appropriate approach to sell profitable products to targeted customers.

Data mining brings a lot of benefits to retail companies in the same way as marketing. Through market basket analysis, a store can have an appropriate production arrangement in a way that customers can buy frequent buying products together with pleasant. In addition, it also helps the retail companies offer certain discounts for particular products that will attract more customers.

2. Finance / Banking

Data mining gives financial institutions information about loan information and credit reporting. By building a model from historical customer's data, the bank and financial institution can determine good and bad loans. In addition, data mining helps banks detect fraudulent credit card transactions to protect credit card's owner.

3. Manufacturing

By applying data mining in operational engineering data, manufacturers can detect faulty equipments and determine optimal control parameters. For example semiconductor manufacturers has a challenge that even the conditions of manufacturing environments at different wafer production plants are similar, the quality of wafer are lot the same and some for unknown reasons even has defects. Data mining has been applying to determine the ranges of control parameters that lead to the production of golden wafer. Then those optimal control parameters are used to manufacture wafers with desired quality.

4. Governments

Data mining helps government agency by digging and analyzing records of financial transaction to build patterns that can detect money laundering or criminal activities.

5. Law enforcement:

Data mining can aid law enforcers in identifying criminal suspects as well as apprehending these criminals by examining trends in location, crime type, habit, and other patterns of behaviors.

6. Researchers:

Data mining can assist researchers by speeding up their data analyzing process; thus, allowing those more time to work on other projects. [7]

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LITERATURE SURVEY

Although personalized search has been proposed for many years and many personalization strategies have been investigated, it is still unclear whether personalization is consistently effective on different queries for different users, and under different search contexts. In this paper, we study this problem and get some preliminary conclusions. We present a large-scale evaluation framework for personalized search based on query logs, and then evaluate five personalized search strategies (including two click-based and three profile-based ones) using 12-day MSN query logs.[8] By analyzing the results, we reveal that personalized search has significant improvement over common web search on some queries but it also has little effect on other queries (e.g., queries with small click entropy). It even harms search accuracy under some situations. Furthermore, we show that straightforward click-based personalization strategies perform consistently and considerably well, while profile-based ones are unstable in our experiments. We also reveal that both long-term and short-term contexts are very important in improving search performance for profile-based personalized search strategies.[9]

We formulate and study search algorithms that consider a user's prior interactions with a wide variety of content to personalize that user's current Web search. Rather than relying on the unrealistic assumption that people will precisely specify their intent when searching, we pursue techniques that leverage implicit information about the user's interests. This information is used to re-rank Web search results within a relevance feedback framework.[10] We explore rich models of user interests, built from both search-related information, such as previously issued queries and previously visited Web pages, and other information about the user such as documents and email the user has read and created. Our research suggests that rich representations of the user and the corpus are important for personalization, but that it is possible to approximate these representations and provide efficient client-side algorithms for personalizing search. We show that such personalization algorithms can significantly improve on current Web search.[11]

Long-term search history contains rich information about a user's search preferences, which can be used as search context to improve retrieval performance. In this paper, we study statistical language modeling based methods to mine

contextual information from long-term search history and exploit it for a more accurate estimate of the query language model. Experiments on real web search data show that the algorithms are effective in improving search accuracy for both fresh and recurring queries. The best performance is achieved when using click through data of past searches that are related to the current query.[12]

Web search engines help users find useful information on the World Wide Web (WWW). However, when the same query is submitted by different users, typical search engines return the same result regardless of who submitted the query. Generally, each user has different information needs for his/her query. Therefore, the search result should be adapted to users with different information needs. In this paper, we first propose several approaches to adapting search results according to each user's need for relevant information without any user effort, and then verify the effectiveness of our proposed approaches.[13] Experimental results show that search systems that adapt to each user's preferences can be achieved by constructing user profiles based on modified collaborative filtering with detailed analysis of user's browsing history in one day.

One hundred users, one hundred needs. As more and more topics are being discussed on the web and our vocabulary remains relatively stable, it is increasingly difficult to let the search engine know what we want. Coping with ambiguous queries has long been an important part of the research on Information Retrieval, but still remains a challenging task. *Personalized search* has recently got significant attention in addressing this challenge in the web search community, based on the premise that a user's general preference may help the search engine disambiguate the true intention of a query.[14] However, studies have shown that users are reluctant to provide any explicit input on their personal preference. In this paper, we study how a search engine can learn a user's preference *automatically* based on her past click history and how it can use the user preference to personalize search results. Our experiments show that users' preferences can be learned accurately even from little click-history data and personalized search based on user preference yields significant improvements over the best existing ranking mechanism in the literature.[15]

SYSTEM STUDY

FEASIBILITY STUDY

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The feasibility of the project is analyzed in this phase and business proposal is put forth with a very general plan for the project and some cost estimates. During system analysis the feasibility study of the proposed system is to be carried out. This is to ensure that the proposed system is not a burden to the company. For feasibility analysis, some understanding of the major requirements for the system is essential.

Three key considerations involved in the feasibility analysis are

- ◆ ECONOMICAL FEASIBILITY
- ◆ TECHNICAL FEASIBILITY
- ◆ SOCIAL FEASIBILITY

ECONOMICAL FEASIBILITY

This study is carried out to check the economic impact that the system will have on the organization. The amount of fund that the company can pour into the research and development of the system is limited. The expenditures must be justified. Thus the developed system as well within the budget and this was achieved because most of the technologies used are freely available. Only the customized products had to be purchased.

TECHNICAL FEASIBILITY

This study is carried out to check the technical feasibility, that is, the technical requirements of the system. Any system developed must not have a high demand on the available technical resources. This will lead to high demands on the available technical resources. This will lead to high demands being placed on the client. The developed system must have a modest requirement, as only minimal or null changes are required for implementing this system.

SOCIAL FEASIBILITY

The aspect of study is to check the level of acceptance of the system by the user. This includes the process of training the user to use the system efficiently. The user must not feel threatened by the system, instead must accept it as a necessity. The level of acceptance by the users solely depends on the methods that are employed to educate the user about the system and to make him familiar with it. His level of confidence must be raised so that he is also able to make some constructive criticism, which is welcomed, as he is the final user of the system.

SYSTEM DESIGN

SYSTEM ARCHITECTURE:

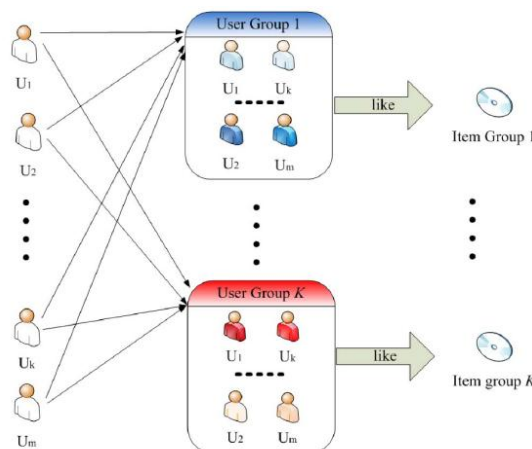


Figure 2: System Architecture

DATA FLOW DIAGRAM:

1. The DFD is also called as bubble chart. It is a simple graphical formalism that can be used to represent a system in terms of input data to the system, various processing carried out on this data, and the output data is generated by this system.
2. The data flow diagram (DFD) is one of the most important modeling tools. It is used to model the system components. These components are the system process, the data used by the process, an external entity that interacts with the system and the information flows in the system.
3. DFD shows how the information moves through the system and how it is modified by a series of transformations. It is a graphical technique that depicts information flow and the transformations that are applied as data moves from input to output.
4. DFD is also known as bubble chart. A DFD may be used to represent a system at any level of abstraction. DFD may be partitioned into levels

that represent increasing information flow and functional detail.

DATA FLOW DIAGRAM

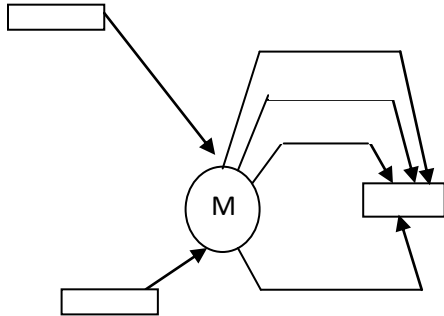


Figure 3: Data Flow Diagram

UML DIAGRAMS

UML stands for Unified Modeling Language. UML is a standardized general-purpose modeling language in the field of object-oriented software engineering. The standard is managed, and was created by, the Object Management Group.

The goal is for UML to become a common language for creating models of object oriented computer software. In its current form UML is comprised of two major components: a Meta-model and a notation. In the future, some form of method or process may also be added to; or associated with, UML.

The Unified Modeling Language is a standard language for specifying, Visualization, Constructing and documenting the artifacts of software system, as well as for business modeling and other non-software systems.

The UML represents a collection of best engineering practices that have proven successful in the modeling of large and complex systems.

The UML is a very important part of developing objects oriented software and the software development process. The UML uses mostly graphical notations to express the design of software projects.

GOALS:

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The Primary goals in the design of the UML are as follows:

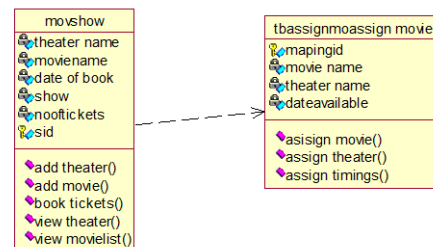
1. Provide users a ready-to-use, expressive visual modeling Language so that they can develop and exchange meaningful models.
2. Provide extendibility and specialization mechanisms to extend the core concepts.
3. Be independent of particular programming languages and development process.
4. Provide a formal basis for understanding the modeling language.
5. Encourage the growth of OO tools market.
6. Support higher level development concepts such as collaborations, frameworks, patterns and components.
7. Integrate best practices.

USE CASE DIAGRAM:

A use case diagram in the Unified Modeling Language (UML) is a type of behavioral diagram defined by and created from a Use-case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases. The main purpose of a use case diagram is to show what system functions are performed for which actor. Roles of the actors in the system can be depicted.

CLASS DIAGRAM:

In software engineering, a class diagram in the Unified Modeling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among the classes. It explains which class contains information.



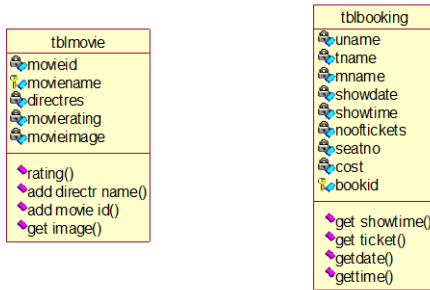


Figure 4: Class Diagram
SEQUENCE DIAGRAM:

A sequence diagram in Unified Modeling Language (UML) is a kind of interaction diagram that shows how processes operate with one another and in what order. It is a construct of a Message Sequence Chart. Sequence diagrams are sometimes called event diagrams, event scenarios, and timing diagrams.

ACTIVITY DIAGRAM:

Activity diagrams are graphical representations of workflows of stepwise activities and actions with support for choice, iteration and concurrency. In the Unified Modeling Language, activity diagrams can be used to describe the business and operational step-by-step workflows of components in a system. An activity diagram shows the overall flow of control.

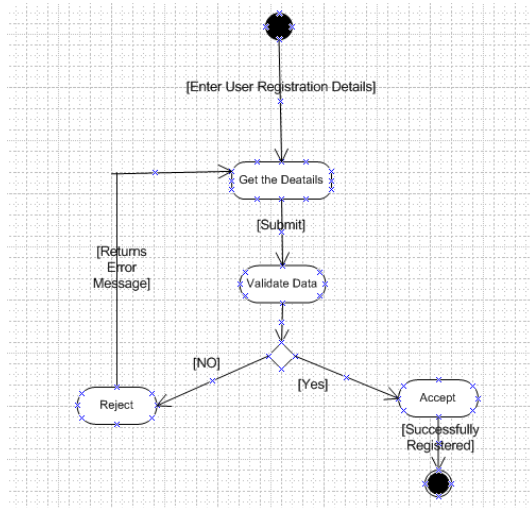


Figure 5: Activity Diagram

Login Activity:

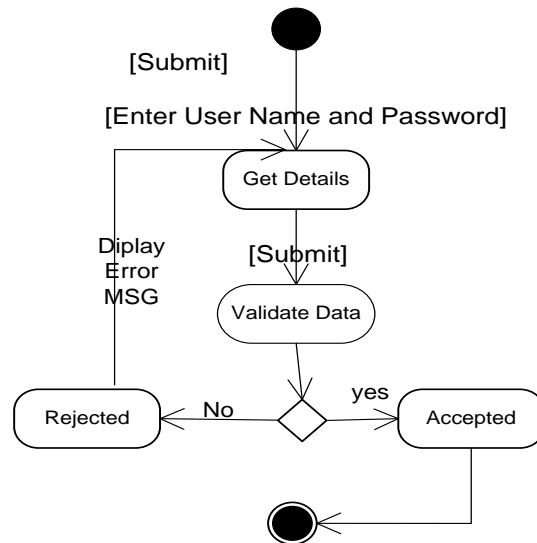


Figure 6: Login Activity

User Master

ADMIN ACTIVITIES

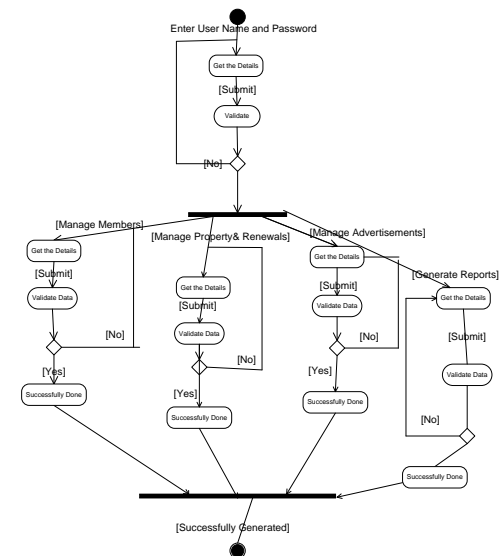


Figure 7: Admin Activities

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INPUT DESIGN

The input design is the link between the information system and the user. It comprises the developing specification and procedures for data preparation and those steps are necessary to put transaction data in to a usable form for processing can be achieved by inspecting the computer to read data from a written or printed document or it can occur by having people keying the data directly into the system. The design of input focuses on controlling the amount of input required, controlling the errors, avoiding delay, avoiding extra steps and keeping the process simple. The input is designed in such a way so that it provides security and ease of use with retaining the privacy. Input Design considered the following things:

- What data should be given as input?
- How the data should be arranged or coded?
- The dialog to guide the operating personnel in providing input.
- Methods for preparing input validations and steps to follow when error occur.

OBJECTIVES

1. Input Design is the process of converting a user-oriented description of the input into a computer-based system. This design is important to avoid errors in the data input process and show the correct direction to the management for getting correct information from the computerized system.

2. It is achieved by creating user-friendly screens for the data entry to handle large volume of data. The goal of designing input is to make data entry easier and to be free from errors. The data entry screen is designed in such a way that all the data manipulates can be performed. It also provides record viewing facilities.

3. When the data is entered it will check for its validity. Data can be entered with the help of screens. Appropriate messages are provided as when needed so that the user

will not be in maize of instant. Thus the objective of input design is to create an input layout that is easy to follow

OUTPUT DESIGN

A quality output is one, which meets the requirements of the end user and presents the information clearly. In any system results of processing are communicated to the users and to other system through outputs. In output design it is determined how the information is to be displaced for immediate need and also the hard copy output. It is the most important and direct source information to the user. Efficient and intelligent output design improves the system's relationship to help user decision-making.

1. Designing computer output should proceed in an organized, well thought out manner; the right output must be developed while ensuring that each output element is designed so that people will find the system can use easily and effectively. When analysis design computer output, they should Identify the specific output that is needed to meet the requirements.

2. Select methods for presenting information.

3. Create document, report, or other formats that contain information produced by the system.

The output form of an information system should accomplish one or more of the following objectives.

- ❖ Convey information about past activities, current status or projections of the
- ❖ Future.
- ❖ Signal important events, opportunities, problems, or warnings.
- ❖ Trigger an action.
- ❖ Confirm an action.

SYSTEM ANALYSIS

EXISTING SYSTEM:

Collaborative filtering (CF) is an important and popular technology for recommender systems. There has been a lot of work done both in industry and academia. These methods are classified into user-based CF and item-based CF. The basic idea of user-based CF approach is to find out a set of users who

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have similar favor patterns to a given user (i.e., “neighbors” of the user) and recommend to the user those items that other users in the same set like, while the item-based CF approach aims to provide a user with the recommendation on an item based on the other items with high correlations (i.e., “neighbors” of the item). In all collaborative filtering methods, it is a significant step to find users’ (or items’) neighbors, that is, a set of similar users (or items). Currently, almost all CF methods measure users’ similarity (or items’ similarity) based on corated items of users (or common users of items). Although these recommendation methods are widely used in E-Commerce.

DISADVANTAGES OF EXISTING SYSTEM:

1. It is difficult to find out correlations between users and items.
2. It occurs when the available data are insufficient for identifying similar users or items.
3. Recommendation accuracy is not efficient.

PROPOSED SYSTEM:

In this paper, we borrow the idea of object typicality from cognitive psychology and propose a typicality-based CF recommendation approach named TyCo. The mechanism of typicality-based CF recommendation is as follows: First, we cluster all items into several item groups. For example, we can cluster all movies into “war movies,” “romance movies,” and so on. Second, we form a user group corresponding to each item group (i.e., a set of users who like items of a particular item group), with all users having different typicality degrees in each of the user groups. Third, we build a user-typicality matrix and measure users’ similarities based on users’ typicality degrees in all user groups so as to select a set of “neighbors” of each user. Then, we predict the unknown rating of a user on an item based on the ratings of the “neighbors” of at user on the item.

ADVANTAGES OF PROPOSED SYSTEM:

1. It improves the accuracy of predictions when compared with previous recommendation methods.

2. It can reduce the number of big-error predictions.
3. It works well even with sparse training data sets.

SYSTEM TESTING

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, sub assemblies, assemblies and/or a finished product. It is the process of exercising software with the intent of ensuring that the Software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of test. Each test type addresses a specific testing requirement.

TYPES OF TESTS

Unit testing

Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application. It is done after the completion of an individual unit before integration. This is a structural testing, that relies on knowledge of its construction and is invasive. Unit tests perform basic tests at component level and test a specific business process, application, and/or system configuration. Unit tests ensure that each unique path of a business process performs accurately to the documented specifications and contains clearly defined inputs and expected results.

Integration testing

Integration tests are designed to test integrated software components to determine if they actually run as one program. Testing is event driven and is more concerned with the basic outcome of screens or fields. Integration tests demonstrate that although the components were individually satisfaction, as shown by successfully unit testing, the combination of components is correct and consistent. Integration testing is specifically aimed at exposing

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the problems that arise from the combination of components.

Functional test

Functional tests provide systematic demonstrations that functions tested are available as specified by the business and technical requirements, system documentation, and user manuals.

Functional testing is centered on the following items:

Valid Input : identified classes of valid input must be accepted.

Invalid Input : identified classes of invalid input must be rejected.

Functions : identified functions must be exercised.

Output : identified classes of application outputs must be exercised.

Systems/Procedures: interfacing systems or procedures must be invoked.

Organization and preparation of functional tests is focused on requirements, key functions, or special test cases. In addition, systematic coverage pertaining to identify Business process flows; data fields, predefined processes, and successive processes must be considered for testing. Before functional testing is complete, additional tests are identified and the effective value of current tests is determined.

System Test

System testing ensures that the entire integrated software system meets requirements. It tests a configuration to ensure known and predictable results. An example of system testing is the configuration oriented system integration test. System testing is based on process descriptions and flows, emphasizing pre-driven process links and integration points.

White Box Testing

White Box Testing is a testing in which in which the software tester has knowledge of the inner workings, structure and language of the software, or at least its purpose. It is purpose. It is used to test areas that cannot be reached from a black box level.

Black Box Testing

Black Box Testing is testing the software without any knowledge of the inner workings, structure or language of the module being tested. Black box tests, as most other kinds of tests, must be written from a definitive source document, such as specification or requirements document, such as specification or requirements document. It is a testing in which the software under test is treated, as a black box .you cannot “see” into it. The test provides inputs and responds to outputs without considering how the software works.

Unit Testing:

Unit testing is usually conducted as part of a combined code and unit test phase of the software lifecycle, although it is not uncommon for coding and unit testing to be conducted as two distinct phases.

Test strategy and approach

Field testing will be performed manually and functional tests will be written in detail.

Test objectives

- All field entries must work properly.
- Pages must be activated from the identified link.
- The entry screen, messages and responses must not be delayed.

Features to be tested

- Verify that the entries are of the correct format
- No duplicate entries should be allowed
- All links should take the user to the correct page.

Integration Testing

Software integration testing is the incremental integration testing of two or more integrated software components on a single platform to produce failures caused by interface defects.

The task of the integration test is to check that components or software applications, e.g. components in a software system or – one step up – software applications at the company level – interact without error.

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Test Results: All the test cases mentioned above passed successfully. No defects encountered.

Acceptance Testing

User Acceptance Testing is a critical phase of any project and requires significant participation by the end user. It also ensures that the system meets the functional requirements.

Test Results: All the test cases mentioned above passed successfully. No defects encountered.

IMPLEMENTATION

MODULES:

1. TyCo Technique
2. Item Typicality Measurement
3. User Typicality Measurement
4. Neighbors Selection
5. Prediction

MODULES DESCRIPTION:

Tyco Technique:

In Tyco, as a user is described by a user typicality vector, each element in the vector can be considered as a feature of a user. Such a representation can indicate the user's preference on items at a higher abstraction level than representing a user by a set of rated items. Furthermore, measuring users' similarity based on users' typicality can overcome the limitation of traditional CF mentioned.

Item Typicality Measurement:

As introduced above, the typicality of an object in a concept depends on the central tendency of the object for the prototype of the concept. In other words, if an object is more similar to the prototype of a concept, it has a higher typicality degree in the concept. Generally, an item is represented by a set of properties, which, following our previous work, we shall call item property vector. For example, keywords, actors, directors, and producers are properties of a movie and these properties can form an item property vector to represent a movie.

User Typicality Measurement:

The prototype of a user group is computed from the properties describing users. Most data sets of existing

recommender systems have little information related to

Users' interests and the ratings of users on items are the main related information for describing users' interests.

Neighbors Selection:

The neighbor selection is a very important step before prediction because the prediction ratings of an active user on items will be inaccurate if the selected neighbors are not sufficiently similar to the active user. Instead of selecting the top-k neighbors, we set a threshold γ for selecting neighbors. The choice of similarity functions depends on applications. There have been a number of methods proposed to calculate the similarity between two objects, as discussed. Here, we consider three methods, namely, distance-based similarity, cosine-based similarity, and correlation-based similarity.

Prediction:

Having obtained the set of "neighbors" of each user, we can predict the rating of an active user U_i on an item O_j , denoted by $R(U_i;O_j)$, based on the ratings of all "neighbors".

RESULTS & CONCLUSION

In this research paper, we investigate the collaborative filtering recommendation from a new perspective and present a novel typicality-based collaborative filtering recommendation method named TyCo. In TyCo, a user is represented by a user typicality vector that can indicate the user's preference on each kind of items. A distinct feature of TyCo is that it selects "neighbors" of users by measuring users' similarity based on their typicality degrees instead of correlated items by users. Such a feature can overcome several limitations of traditional collaborative filtering methods. It is the first work that applies typicality for collaborative filtering. We conduct experiments to evaluate TyCo and demonstrate the advantages of TyCo. In TyCo, there are some preprocessing procedures, such as constructing user prototype by clustering and measuring user typicality in user groups. The cost of

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these preprocessing procedures depends on the particular clustering method used. In real-life applications, these procedures can be processed offline. While users' prototypes are constructed, the remained recommendation process which is based on user typicality will be efficient. For large scale applications, we can also first conduct the above preprocessing offline, and then adopt some parallel computing methods (e.g., MapReduce) to speed up the computing.

There are several possible future extensions to our work. In TyCo, we do not specify how to cluster resources so as to find out item groups and the corresponding user groups. One possible future work is to try different clustering methods and see how the recommendation results are affected. How to using parallel computing methods (e.g., MapReduce) to handle the large scale applications is also one of the possible future works.

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