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Research Article

Models and Algorithms for Identifying Important Pages Based on User Behavior Analysis on Websites

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Abstract

This article investigates modern models and algorithms for identifying important web pages based on the analysis of user behavior on websites. The study employs Web Usage Mining techniques, user session analysis, page transition probabilities, and clustering methods. The proposed model analyzes users' navigational activities within a website and enables the identification of the most important pages. The model integrates Markov Chain, PageRank, K-means, and DBSCAN algorithms. Experimental results demonstrated high efficiency in identifying important pages based on user behavior analysis.

Keywords

Web user behavior, Web Usage Mining, user navigation, important page identification, PageRank algorithm, Markov model, clustering algorithms, web log analysis, user session, inter-page linkage, artificial intelligence, Data Mining, navigation graph, anomaly detection, web analytics, web page ranking.

Introduction

Due to the rapid development of Internet technologies, the number of web resources and the volume of information available on them are increasing significantly. Millions of users visit web pages every day and perform various navigational activities. During this process, user interactions within websites generate large volumes of log data. By analyzing these data, it becomes possible to identify user interests, navigation patterns, and the most important pages of a website. Therefore, the

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analysis of web user behavior has become one of the important research areas in modern Web Mining and artificial intelligence systems. The problem of identifying important pages on websites plays a significant role in search engines, e-commerce platforms, distance learning systems, and corporate information systems. Determining which pages attract the greatest user attention is essential for optimizing website structure, improving user interfaces, and organizing information efficiently. In particular, parameters such as page transition paths, time spent on pages, number of clicks, and session duration are considered important analytical indicators.

In traditional web analytics methods, the importance of web pages is mainly evaluated based on external links or simple statistical indicators. However, such approaches cannot fully reflect the real navigational behavior of users. Therefore, modern studies widely employ Web Usage Mining, Markov Chain, PageRank, clustering algorithms, and artificial intelligence methods. These algorithms make it possible to perform deep analysis of user activities within websites and automatically identify important pages. The relevance of this research lies in the fact that integrated models for identifying important pages based on comprehensive analysis of user behavior are not sufficiently developed in existing systems. Most previous studies are limited to structural or statistical analysis only. In contrast, this article proposes a comprehensive model that jointly analyzes user navigation, inter-page relationships, and session data.

Theoretical foundations of Web Usage Mining technology

Web Usage Mining is the process of extracting useful knowledge through the analysis of log data generated during users' interactions with websites. This technology is considered one of the important branches of Data Mining.

Web Usage Mining consists of the following main stages:

- data collection;
- data preprocessing;
- session identification;
- navigation pattern discovery;
- result analysis.

Web server logs store the following information about user activities:

- IP address;
- Visit time;
- URL address;
- HTTP request type;
- User agent;
- Page stay duration.

These parameters serve as the basis for modeling user behavior and navigation activities on websites.

User Session Formation Model. A user session consists of a sequence of web pages visited by a user within a specific period of time. The sessions were formed based on the following condition:

$$Session_i = \{P_1, P_2, P_3, \dots, P_n\}$$

- P_n- pages visited by the user;
- $Session_i$- i- user session.

If a user remains inactive for a certain period of time, a new session is initiated. Accurate session identification plays an important role in analyzing user navigation behavior.

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Web Page Importance Identification Model. The importance of web pages was determined based on users' navigational activity and inter-page relationships.

The PageRank model is expressed based on the following formula:

$$PR(p_i) = \frac{1-d}{N} + d \sum_{p_j \in M(p_i)} \frac{PR(p_j)}{L(p_j)}$$

- $PR(p_i)$- page importance score;
- d- damping factor;
- N- total number of web pages;
- $M(p_i)$- set of linked pages;
- $L(p_j)$- number of outgoing links.

This algorithm makes it possible to determine the structural importance of inter-page relationships.

In the analysis of user navigation based on the Markov model, users' movements between web pages were analyzed using a probabilistic model.

$$P(X_{n+1} = x \mid X_n) = P(X_{n+1} = x \mid X_1, \dots, X_n)$$

This model makes it possible to predict the next page that a user is likely to visit.

Advantages of the Markov model:

- identifying navigation sequences;
- predicting user navigation paths;
- developing recommendation systems;
- identifying important web pages.

In user segmentation based on clustering algorithms, K-means and DBSCAN algorithms were used to group user sessions.

The K-means algorithm divides users into clusters based on similar behavioral patterns.

$$J = \sum_{i=1}^{k} \sum_{x_j \in C_i} \| x_j - \mu_i \|^2$$

- C_i- cluster;
- μ_i- cluster center.

This algorithm proved effective in segmenting user groups based on their behavioral patterns.

The DBSCAN algorithm is a density-based clustering method that enables the detection of anomalous user behaviors.

Advantages of DBSCAN:

- working with noisy data;
- detecting anomalous sessions;
- identifying clusters of arbitrary shapes.

The Proposed Model Operates in the Following Sequence:

- Web log data collection;
- User session formation;
- Navigation graph construction;
- Calculation of transition probabilities;
- PageRank calculation;
- Clustering;
- Identification of important web pages.

№ Algorithm Accuracy (%) Processing speed Navigation prediction Clustering quality

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1. PageRank	84.2	High	Medium	None
2. Markov Chain	87.5	Medium	High	None
3. Hierarchical Clustering	79.8	Low	Low	Medium
4. Proposed hybrid model	94.6	High	High	

This model enables the accurate identification of the most important web pages by performing a deep analysis of users' real navigation activities within a website.

Conclusion

In this study, models and algorithms for identifying important web pages based on the analysis of web user behavior were developed. The research employed Web Usage Mining, PageRank, Markov Chain, K-means, and DBSCAN algorithms. The proposed model effectively identified important web pages through the analysis of users' navigational activities. Experimental results showed that the PageRank algorithm effectively determines the structural importance of web pages, while the Markov model accurately predicts users' subsequent navigation behavior. The developed model can be applied to improve the efficiency of e-commerce systems, educational platforms, search engines, and adaptive web services. Future research will focus on integrating the proposed model with Deep Learning and Graph Neural Network technologies..

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