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## Sequence-Aware Recommender Systems

Massimo Quadrana, Paolo Cremonesi, Dietmar Jannach

Recommender systems are one of the most successful applications of data mining and machine-learning technology in practice. Academic research in the field is historically often based on the matrix completion problem formulation, where for each user-item-...

A Highlights ∨

**Abstract**
Recommender systems are one of the most successful applications of data mining and machine- learning technology in practice.
Based on this review, we propose a categorization of the corresponding recommendation tasks and goals, summarize existing algorithmic solutions, discuss methodological approaches when benchmarking what we call sequence-aware recommender systems, and outline open challenges in the area.

**Full Text**
Sequence-Aware Recommender Systems MASSIMO QUADRANA, ContentWise PAOLO CREMONESI, Politecnico di Milano DIETMAR JANNACH, AAU Klagenfurt Recommender systems are one of the most successful applications of data mining and machine- learning technology in practice.
This abstraction is generally well-suited to train machine- learning models that aim to capture longer-term user preference profiles.
Context- Aware and Time-Aware Recommender Systems. In some of the application scenarios discussed in the next sections, sequence-aware recommender systems represent a special form of context- aware recommender systems.

**Subject**
Machine learning
Recommender systems

**RESEARCH-ARTICLE** FREE

## A Context-Aware User-Item Representation Learning for Item Recommendation

👤 Libing Wu, 👤 Cong Quan, 👤 Chenliang Li, 👤 Qian Wang, 👤 Bolong Zheng,

👤 Xiangyang Luo

Both reviews and user-item interactions (i.e., rating scores) have been widely adopted for user rating prediction. However, these existing techniques mainly extract the latent representations for users and items in an independent and static manner. That ...

A Highlights ⌄

### Abstract

In this article, we propose a novel context- aware user-item representation learning model for rating prediction, named CARL.
Also, with the attention mechanism, we show that the pair-based relevant information (i.e., context- aware information) in reviews can be highlighted to interpret the rating prediction for different user-item pairs.

### Full Text

Moreover, it is beneficial in alleviating the data sparsity and coldstart issues for recommender systems.
Textual information (e.g., users' reviews, item description or labels) is the most popular auxiliary information available in many recommender systems.
Though these existing attention-based recommender systems improve recommendation performance and also the interpretability of recommender systems, they also neglect the diverse and complex interactions between users and items.

### Subject

Machine learning
Recommender systems
Machine learning approaches

🗩 ➕ • 🗗 🗟 🗎

**RESEARCH-ARTICLE** FREE

## Sound and Music Recommendation with Knowledge Graphs

Sergio Oramas, Vito Claudio Ostuni, Tommaso Di Noia, Xavier Serra,

Eugenio Di Sciascio

The Web has moved, slowly but steadily, from a collection of documents towards a collection of structured data. Knowledge graphs have then emerged as a way of representing the knowledge encoded in such data as well as a tool to reason on them in order ...

A Highlights ⌄

**Abstract**
Knowledge graphs are currently used, for example, to explain search results, to explore knowledge spaces, to semantically enrich textual documents, or to feed knowledge-intensive applications such as recommender systems. In this work, we describe how to create and exploit a knowledge graph to supply a hybrid recommendation engine with information that builds on top of a collections of documents describing musical and sound items.

**Full Text**
In the past few years with the availability of Linked Open Data (LOD) datasets, a new class of recommender systems has emerged that can be named LOD-based recommender systems.
A context- aware music recommender system that infers contextual information based on the most recent sequence of songs liked by the user is presented in Hariri et al. [2012].
Summing up, knowledge graphs can be a useful tool when properly leveraged within recommender systems for musical items.

**Keywords**
music
recommender systems

**Subject**
Recommender systems

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## A Bayesian framework for learning rule sets for interpretable classification

👤 Tong Wang, 👤 Cynthia Rudin, 👤 Finale Doshi-Velez, 👤 Yimin Liu,

👤 Erica Klampfl, 👤 Perry MacNeille

We present a machine learning algorithm for building classifiers that are comprised of a *small* number of *short* rules. These are restricted disjunctive normal form models. An example of a classifier of this form is as follows: *If X* satisfies (condition *A ...*

A Highlights ⌄

**Abstract**
We present a machine learning algorithm for building classifiers that are comprised of a small number of short rules.
We apply our method (Bayesian Rule Sets − BRS) to characterize and predict user behavior with respect to in−vehicle context− aware personalized recommender systems.

**Full Text**
Context− aware recommender systems. In Proc of the 2008 ACM Conf on Rec Systems, RecSys '08, pages 335-336, New York, NY, USA, 2008.
Context− aware recommender systems for learning: a survey and future challenges. IEEE Transactions on Learning Technologies, 5(4):318-335, 2012.
Bayesian or's of and's for interpretable classification with application to context aware recommender systems.

**Subject**
Machine learning

## Parallel and Distributed Collaborative Filtering: A Survey

Efthalia Karydi, Konstantinos Margaritis

Collaborative filtering is among the most preferred techniques when implementing recommender systems. Recently, great interest has turned toward parallel and distributed implementations of collaborative filtering algorithms. This work is a survey of ...

A Highlights ⌄

**Abstract**
Collaborative filtering is among the most preferred techniques when implementing recommender systems.

**Full Text**
Mahout [Apache Mahout 2016] is a framework adequate for the development of machine learning applications.
A detailed presentation of the field of recommender systems and the most popular techniques used, such as collaborative filtering, content-based filtering, data mining, and context- aware systems, are detailed in Ricci et al. [2011] and Jannach et al. [2011].
Context- aware technology-enhanced recommender systems are discussed by Verbert et al. [2012], and a classification framework of the context information that divides the contextual information into eight categories is introduced.

**Keywords**
recommender systems

**EDITORIAL**   FREE

## Introduction to Intelligent Music Systems and Applications

Markus Schedl, Yi-Hsuan Yang, Perfecto Herrera-Boyer

Intelligent technologies have become an essential part of music systems and applications. This is evidenced by today's omnipresence of digital online music stores and streaming services, which rely on music recommenders, automatic playlist generators, ...

A Highlights ∨

**Abstract**

Intelligent technologies have become an essential part of music systems and applications. This is evidenced by today's omnipresence of digital online music stores and streaming services, which rely on music recommenders, automatic playlist generators, and music browsing interfaces. A large amount of research leading to intelligent music applications deals with the extraction of musical and acoustic information directly from the audio signal using signal processing techniques.
In this editorial, we discuss the notion of "intelligent music system" and give an overview of the papers selected to this special issue.

**Full Text**

CCS Concepts:r Applied computing → Sound and music computing Additional Key Words and Phrases: Intelligent music systems, machine learning, music information retrieval ACM Reference Format: Markus Schedl, Yi-Hsuan Yang, and Perfecto Herrera-Boyer. 2016.

Two examples of IMSs, which are quite different from the previously described systems, offer personalized and context- aware music recommendations: Just-for-Me [Cheng and Shen 2014] and Mobile Music Genius [Schedl et al. 2014]. Sophisticated music recommender systems that interact with their users could be considered as a primitive form of IMSs, notwithstanding that their behavior is restricted to updating a recommendation list based on user feedback and interaction traces.

**Keywords**
machine learning

**Subject**
Sound and music computing

## Quantitative Study of Music Listening Behavior in a Smartphone Context

Yi-Hsuan Yang,   Yuan-Ching Teng

Context-based services have attracted increasing attention because of the prevalence of sensor-rich mobile devices such as smartphones. The idea is to recommend information that a user would be interested in according to the user's surrounding context. ...

A **Highlights** ∨                                                    🔗¹

### Abstract

In light of this fact, we present in this article a quantitative study of the personal, situational, and musical factors of musical preference in a smartphone context, using a new dataset comprising the listening records and self-report context annotation of 48 participants collected over 3wk via an Android app.
We investigate 3 core research questions evaluating the strength of a rich set of low-level and high-level audio features for music usage auto-tagging (i.e., music preference in different user activities), the strength of time-domain and frequency-domain sensor features for user activity classification, and how user factors such as personality traits are correlated with the predictability of music usage and user activity, using a closed set of 8 activity classes. We provide an in-depth discussion of the main findings of this study and their implications for the development of context-based music services for smartphones.

### Full Text

Best usage context prediction for music tracks. In Proceedings of the Workshop on Context Aware Recommender Systems.
A user-centric evaluation framework for recommender systems. In Proceed ings of the ACM International Conference on Recommender Systems. 157-164.
Context- aware music recommender systems. In Proceedings of the International Workshop on Advances in Music Information Research. 865-866.

### Subject

Sound and music computing
Music retrieval

**RESEARCH-ARTICLE**  FREE

# Deep Learning Based Recommender System: A Survey and New Perspectives

Shuai Zhang, Lina Yao, Aixin Sun, Yi Tay

With the growing volume of online information, recommender systems have been an effective strategy to overcome information overload. The utility of recommender systems cannot be overstated, given their widespread adoption in many web applications, along ...

A  Highlights ⌄

**Abstract**
With the growing volume of online information, recommender systems have been an effective strategy to overcome information overload.
The influence of deep learning is also pervasive, recently demonstrating its effectiveness when applied to information retrieval and recommender systems research.
This article aims to provide a comprehensive review of recent research efforts on deep learning-based recommender systems.

**Full Text**
Other notations and denotations will be introduced in corresponding sections. 2.2 Deep Learning Techniques Deep learning can be generally considered a subfield of machine learning.
ConTagNet [119] is a context- aware tag recommender system. The image features are learned by CNNs. The context representations are processed by a two-layer fully connected feedforward neural network.
Smirnova et al. [133] proposed a context- aware session-based recommender system based on conditional RNNs.

**Subject**
Recommender systems

**RESEARCH-ARTICLE**  FREE

## Structural Analysis of User Choices for Mobile App Recommendation

👤 Bin Liu, 👤 Yao Wu, 👤 Neil Zhenqiang Gong, 👤 Junjie Wu, 👤 Hui Xiong,

👤 Martin Ester

Advances in smartphone technology have promoted the rapid development of mobile apps. However, the availability of a huge number of mobile apps in application stores has imposed the challenge of finding the right apps to meet the user needs. Indeed, ...

A Highlights ⌄

**Full Text**
CCS Concepts:r Information systems → Data mining; Recommender systems; Electronic commerce; Additional Key Words and Phrases: Recommender systems, mobile apps, hierarchy structure, structural choices This article was supported in part by the Natural Science Foundation of China (71329201) and the Rutgers 2015 Chancellor's Seed Grant Program.
Stochastic gradient ascent (descent) has been widely used for many machine learning tasks [Bottou 2010].
Karatzoglou et al. [2012] provided a context- aware recommendation using tensor factorization by including context information such as location, moving status, and time.

**Keywords**
recommender systems

**Subject**
Recommender systems

## Modeling Embedding Dimension Correlations via Convolutional Neural Collaborative Filtering

👤 Xiaoyu Du, 👤 Xiangnan He, 👤 Fajie Yuan, 👤 Jinhui Tang, 👤 Zhiguang Qin,

👤 Tat-Seng Chua

As the core of recommender systems, collaborative filtering (CF) models the affinity between a user and an item from historical user-item interactions, such as clicks, purchases, and so on. Benefiting from the strong representation power, neural ...

A Highlights ˅

**Abstract**
As the core of recommender systems, collaborative filtering (CF) models the affinity between a user and an item from historical user-item interactions, such as clicks, purchases, and so on.

**Full Text**
Modern recommender systems typically rely on collaborative filtering (and/or its content/ context - aware variants) to predict a user's preference on unknown items [2, 15, 29, 66].
Soon after MF was introduced to recommender systems, it became prevalent in recommendation research with many variants developed.
In most practical recommender systems, users usually only focus on the top-ranked items rather than all rating scores.

**Subject**
Machine learning
Recommender systems
Machine learning approaches

## SPrank: Semantic Path-Based Ranking for Top-*N* Recommendations Using Linked Open Data

Tommaso Di Noia, Vito Claudio Ostuni, Paolo Tomeo,

Eugenio Di Sciascio

In most real-world scenarios, the ultimate goal of recommender system applications is to suggest a short ranked list of items, namely top-*N* recommendations, that will appeal to the end user. Often, the problem of computing top-*N* recommendations is ...

A  Highlights  ∨

**Abstract**
Experiments with three datasets related to different domains (books, music, and movies) prove the effectiveness of our approach compared to state-of-the-art recommendation algorithms.

**Full Text**
Exploiting the Web of Data in model-based recommender systems. In Proceedings of the 6th ACM Conference on Recommender Systems ( RecSys'12).
Combining distributional semantics and entity linking for context- aware content-based recommendation.
Knowledge infusion into content-based recommender systems. In Proceedings of the 3rd ACM Conference on Recommender Systems ( RecSys'09).

## Top-N Recommendation with Multi-Channel Positive Feedback using Factorization Machines

👤 Babak Loni, 👤 Roberto Pagano, 👤 Martha Larson, 👤 Alan Hanjalic

User interactions can be considered to constitute different feedback channels, for example, view, click, like or follow, that provide implicit information on users' preferences. Each implicit feedback channel typically carries a unary, positive-only ...

A Highlights ⌄

**Full Text**
However, FMs represent the state-of-the-art of context- aware recommendation [25] and have been shown to outperform their closest competitor, which is Multiverse Recommendation [7]. The newer extended variations of FMs [6, 17, 31] have also been shown to be effective for context- aware collaborative filtering. FMs have been successfully applied in context- aware recommendation [25], cross-domain collaborative filtering [16], and social recommendations [13].

**Subject**
Machine learning
Recommender systems
Machine learning approaches

## Version-Aware Rating Prediction for Mobile App Recommendation

👤 Yuan Yao, 👤 Wayne Xin Zhao, 👤 Yaojing Wang, 👤 Hanghang Tong,

👤 Feng Xu, 👤 Jian Lu

With the great popularity of mobile devices, the amount of mobile apps has grown at a more dramatic rate than ever expected. A technical challenge is how to recommend suitable apps to mobile users. In this work, we identify and focus on a unique ...

A Highlights ⌄

**Full Text**
In Proceedings of the 7th ACM Conference on Recommender Systems ( RecSys'13). ACM, New York, NY, 93-100.
In Proceedings of the 4th ACM Conference on Recommender Systems ( RecSys'10). ACM, New York, NY, 135-142.
In Proceedings of the 6th ACM Conference on Recommender Systems ( RecSys'12). ACM, New York, NY, 67-74.

**Keywords**
recommender systems

**RESEARCH-ARTICLE**   FREE

## RecRules: Recommending IF-THEN Rules for End-User Development

Fulvio Corno,    Luigi De Russis,    Alberto Monge Roffarello

Nowadays, end users can personalize their smart devices and web applications by defining or reusing IF-THEN rules through dedicated End-User Development (EUD) tools. Despite apparent simplicity, such tools present their own set of issues. The emerging ...

A Highlights ⌄

**Abstract**
Results are promising: they show the effectiveness of our approach with respect to other state-of-the-art algorithms and open the way for a new class of recommender systems for EUD that take into account the actual functionality needed by end users.

**Full Text**
Starting from iCAP [13], a visual rule-based system for PC to create context- aware applications, there has been a long story of interest in EUD.
Several works on ontological recommender systems have been proposed in the literature [2, 6, 41, 49] with the aim of improving the performance of recommender systems, and to overcome some drawbacks of collaborative methods such as cold start and data sparsity.
Contextually to the progression of LOD-based recommender systems, recommendation methods based on generic heterogeneous networks have recently emerged.

**Subject**
Recommender systems
Machine learning

**RESEARCH-ARTICLE**  PUBLIC ACCESS

## Understanding the Role of Places and Activities on Mobile Phone Interaction and Usage Patterns

Abhinav Mehrotra,   Sandrine R. Müller,   Gabriella M. Harari,

Samuel D. Gosling,   Cecilia Mascolo,   Mirco Musolesi,   Peter J. Rentfrow

User interaction patterns with mobile apps and notifications are generally complex due to the many factors involved. However a deep understanding of what influences them can lead to more acceptable applications that are able to deliver information at ...

A  **Highlights**  ∨

**Full Text**
These affordances have opened the possibility of implementing novel context-aware and personalized applications that are able to assist us in a variety of day-to-day situations.
Context- aware recommender systems. In Recommender Systems Handbook. [6] Brian P Bailey and Joseph A Konstan. 2006.
ContextPhone: A prototyping platform for context- aware mobile applications. IEEE Pervasive Computing 4, 2 (2005), 51-59. [32] Ahmad Rahmati, Chad Tossell, Clayton Shepard, Philip Kortum, and Lin Zhong. 2012.

## Collaborative Intent Prediction with Real-Time Contextual Data

👤 Yu Sun, 👤 Nicholas Jing Yuan, 👤 Xing Xie, 👤 Kieran McDonald, 👤 Rui Zhang

Intelligent personal assistants on mobile devices such as Apple's Siri and Microsoft Cortana are increasingly important. Instead of passively reacting to queries, they provide users with brand new proactive experiences that aim to offer the right ...

A Highlights ⌄

**Full Text**

CCS Concepts:r Information systems → Recommender systems; Collaborative filtering; Personalization;r Human-centered computing → Personal digital assistants;r Computing methodologies → Factor analysis; Online learning settings; Additional Key Words and Phrases: Proactive experiences, personal assistants, nowcasting, streaming context ACM Reference Format: Yu Sun, Nicholas Jing Yuan, Xing Xie, Kieran McDonald, and Rui Zhang. 2017.

Although a few context- aware recommendation models [Adomavicius and Tuzhilin 2011; Liu et al. 2013] have looked at the context, the considered context usually contains only signals about physical environments, and their combinations are fixed and enumerable, for example, 24 hours × 7 days × location types such as home and office [Karatzoglou et al. 2010; Wang et al. 2016; Zhu et al. 2015].

Context- Aware Recommendations. Besides time, context- aware recommendation models [Adomavicius and Tuzhilin 2011; Liu et al. 2013] try to incorporate more evidence of a specific situation such as the location, device, purchasing purpose, and so on, to model the user preferences on unseen items.

**Subject**
Recommender systems
Machine learning
Machine learning approaches

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## LFTF: a framework for efficient tensor analytics at scale

👤 Fan Yang, 👤 Fanhua Shang, 👤 Yuzhen Huang, 👤 James Cheng, 👤 Jinfeng Li,

👤 Yunjian Zhao, 👤 Ruihao Zhao

Tensors are higher order generalizations of matrices to model multi-aspect data, e.g., a set of purchase records with the schema (user_id, product_id, timestamp, feedback). Tensor factorization is a powerful technique for generating a model from a ...

A Highlights ∨

**Abstract**
Though having a broad range of applications, tensor factorization has not been popularly applied compared with matrix factorization that has been widely used in recommender systems, mainly due to the high computational cost and poor scalability of existing tensor factorization methods.

**Full Text**
One of the representative applications of matrix factorization is recommender systems. For example, matrix factorization has been shown to be the superior collaborative filtering approach than neighborhood methods according to the Netflix Prize competition [5].
Application I: Recommender Systems. Tensor factorization is a typical technique for context- aware collaborative filtering [7, 16], as an improvement to the factorization of a matrix that does not integrate other aspects (i.e., the context) into the model.
One straightforward solution is to implement SGD upon the Parameter Server framework [20, 32], which is a general framework for distributed machine learning.

## Tensors for Data Mining and Data Fusion: Models, Applications, and Scalable Algorithms

Evangelos E. Papalexakis, Christos Faloutsos, Nicholas D. Sidiropoulos

Tensors and tensor decompositions are very powerful and versatile tools that can model a wide variety of heterogeneous, multiaspect data. As a result, tensor decompositions, which extract useful latent information out of multiaspect data tensors, have ...

A Highlights ∨

**Full Text**

All the aforementioned surveys are great summaries of the work in a vast research area that spans the fields of chemometrics, psychometrics, signal processing, data mining, and machine learning.

Whether because of corruption, faulty measurements, or incomplete information (e.g., in recommender systems), there is a need to equip our algorithms with the ability to handle missing data.

The method beats Matrix Factorization techniques as well as other Context- Aware Techniques that may (partially) ignore the higher-order structure of the data that the tensor decomposition exploits.

**Subject**

Machine learning

Machine learning approaches

**RESEARCH-ARTICLE** FREE

## Smartphone App Usage Prediction Using Points of Interest

Donghan Yu, Yong Li, Fengli Xu, Pengyu Zhang, Vassilis Kostakos

In this paper we present the first population-level, city-scale analysis of application usage on smartphones. Using deep packet inspection at the network operator level, we obtained a geo-tagged dataset with more than 6 million unique devices that ...

A Highlights ∨

**Full Text**
This metric is often used for recommender systems, because such systems typically recommend a list of items and expect users to click at least one of them.
Thus, we investigate how our technique works in this case, which effectively resembles the cold start problem in recommender systems.
Yu et al. [37] proposed to mine user context logs (including location information) through topic models for personalized context- aware recommendation.

**Subject**
Machine learning
Machine learning algorithms

## Evaluation-as-a-Service for the Computational Sciences: Overview and Outlook

Frank Hopfgartner, Allan Hanbury, Henning Müller, Ivan Eggel,

Krisztian Balog, Torben Brodt, Gordon V. Cormack, Jimmy Lin,

Jayashree Kalpathy-Cramer, Noriko Kando, Makoto P. Kato,

Anastasia Krithara, Tim Gollub, Martin Potthast, Evelyne Viegas,

Simon Mercer

Evaluation in empirical computer science is essential to show progress and assess technologies developed. Several research domains such as information retrieval have long relied on systematic evaluation to measure progress: here, the Cranfield paradigm ...

A Highlights ∨

### Abstract
Crowdsourcing has also changed the way in which industry approaches problem-solving with companies now organizing challenges and handing out monetary awards to incentivize people to work on their challenges, particularly in the field of machine learning.

### Full Text
The potentials of recommender systems challenges for student learning. In Proceedings of the Challenges in Machine Learning: Gaming and Education (CiML'16).
Offline evaluation of recommender systems: All pain and no gain? In Proceedings of the International Workshop on Reproducibility and Replication in Recommender Systems Evaluation (RepSys'13).
In Proceedings of the Poster Track of the 10th ACM Conference on Recommender Systems ( RecSys'16). Karen Spärck Jones and Cornelius Joost van Rijsbergen. 1975.

**RESEARCH-ARTICLE**  **FREE**

## Beyond Interruptibility: Predicting Opportune Moments to Engage Mobile Phone Users

Martin Pielot,    Bruno Cardoso,    Kleomenis Katevas,    Joan Serrà,

Aleksandar Matic,    Nuria Oliver

Many of today's mobile products and services engage their users proactively via push notifications. However, such notifications are not always delivered at the right moment, therefore not meeting products' and users' expectations. To address this ...

A Highlights ∨

**Abstract**
Based on 120 Million phone-use events and 78,930 questionnaire notifications, we build a machine- learning model that before delivering a notification predicts whether a participant will click on the notification and subsequently engage with the offered content.

**Full Text**
Hiniker el al. [17] implemented a classifier to distinguish whether the phone is used in a goal-oriented fashion or in a ritualistic fashion without a clear goal in mind – hypothesizing that the latter state would be useful for recommender systems. Machine learning models are able to leverage complex interactions (both linear and non-linear) between the available features and the ground truth target variable. Feature cleaning is a standard procedure in machine learning to, for instance, deal with missing values or to convert categorical variables into numerical values.

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## Recommender system for learning objects based in the fusion of social signals, interests, and preferences of learner users in ubiquitous e-learning systems

Alessandro Dias,   Leandro K. Wives

In this paper, we present a recommendation approach for learning objects (LOs) in ubiquitous e-learning systems. Many of these systems are social learning networks, and learners can interact with other users through forums or chats. In these systems, ...

A Highlights ⌄

**Full Text**

The most popular classifier is the Nearest Neighbor classifier (kNN), an instance-based machine learning method.

Nowadays recommender systems are used to recommend a wide range of items, including consumer products, movies, music, friends, news, restaurants, and more. We organized them into three groups: User Behavior as Implicit Feedback, Similarity Computation i n N earest Neighbor Recommendation Methods, and Question Words in Ubiquitous Systems and Context- aware Recommender Systems. 3.1 User behavior as implicit feedback In collaborative recommender systems, the past behavior of the user has been used in many works as a source of information for the recommendation process.

## RuleSelector: Selecting Conditional Action Rules from User Behavior Patterns

Vijay Srinivasan, Christian Koehler, Hongxia Jin

Modern smartphones and ubiquitous computing systems collect a wealth of context data from users. Conditional action rules, as popularized by the IFTTT (If-This-Then-That) platform, are a popular way for users to automate frequently repeated tasks or ...

A  Highlights  ⌄

**Full Text**
Context recognition can also enrich user experience by allowing users to speciicy context- aware conditional action rules.
There exists signiicant research in the Ubicomp community on approaches for action prediction, primarily focusing on app prediction [3, 15, 42, 50, 57], and location or activity prediction [9, 30ś32, 45, 49, 55, 59, 60], using inductive machine learning techniques such as SVMs, neural networks, and probabilistic graphical models.
Even though privacy concerns are not new for context aware applications ([7], [19], [1]), we nevertheless encountered them during our study.

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