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# Importance of Context in Prediction Systems of Mobile Applications

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***Abstract*: Many traditional systems give recommendations to the users based on their past history without considering the context of the situation the user is in currently. Such systems may be good at prediction based on the past but do not consider the rapidly changing environment and the prediction may not be the best for the user. Context personalized to the user is important because it explains the situation the user is in. The recommendations to the user should also change according to the various contexts present. Context often represents the hidden state information that the user is in currently. Many systems often take into consideration the location of the user because the situation of the user generally changes with the location. In this paper, we explain why context is important while predicting results for the users by reviewing a set of papers where different contexts such as weather, time, location, user preference, and activity have been taken into consideration. These papers have taken context such that the recommendations to users change dynamically according to their situation or location and these recommendations can be of various forms such as search results or targeted advertisement. Location based Services, Location based advertisement and several types of context have also been discussed in the paper. A general architecture of context-aware systems has also been proposed. Several real world companies also make use of this contextual information so that the user has a dynamic user experience where all the states which might affect his decision making are taken into consideration.***

***Keywords:* Context-aware, Recommendation systems, Location-based context, Time-based context**

## I. INTRODUCTION

In order to understand the relation between the user and the application, we require information that is referred to as context. The location of the user (the latitude and longitude), the time, specific actions, or activities performed by the user can be an example of the context. Suggestions provided based on a user's past content, and data are static in nature. A context of attributes such as geo-location, time of the day, day of the week, etc. will help provide more appropriate recommendations. Context is thus needed to provide a user, services, and recommendations specifically according to his/her needs in that current, real-time context.

Even with a surge in the use of mobile phones and the internet, obtaining relevant items for each user based on real-time features is scarce. Context-based Recommendation System aims at recommending specific data to a user based on real-time context which could be based on a situation, time, or location. It is a user-specific classification problem. This type of system is beneficial for humans because it provides information to users as per changing user needs.

The food delivery application, Zomato, is the best example of context-aware applications. Consider the scenario where a user stays in a certain city A where he uses the app regularly to order food. The application understands the user's behavior and recommends places based on his past orders and eating choices. This application takes into account the location of the user as its context and recommends places nearby. When the user moves to another city B for some work and decides to use the application, the application takes into account the current location of the user and based on his previous habits, recommends him nearby places where he can order food. Now if the application would not have taken the location of the user as its context, it would have suggested places that are far away from the user and hence the order delivery would be infeasible. This is why context is essential for many applications these days.

While browsing through news one must be interested in news particular to his neighborhood, city or country. The person may be interested in international news, but what happens in his city, state, or country may be more important to him. That's why when news sites show news to that person, the location and time of the news matter. The person would be more interested in news about a fire in his neighborhood than what happens between other countries.

Media service provider, Netflix, gains insights and context for each user profile not only via the choices made by them in the past but also taking into account the present conditions. The recommendation algorithm also takes into account the time of the day, the type of streaming device and the duration of viewing content. Although the predictions based on viewing history are an important part of their recommendation system, they deliver precise personalized recommendations based on the present context for the users. Netflix even displays the percentage match for each recommendation given to the user.

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These practical applications demonstrate how context plays an important role in prediction.

## II. LOCATION-BASED SERVICES & ADVERTISEMENT

Location-based services (LBS) - These are the services that are offered through the phone and which takes into account the phone's location. These services generally provide general or entertainment-related information based on the user's location.
Example: Any application which uses GPS can be an example of Location-based services - getting the news based on your location, restaurant suggestion based on the current location, etc. Applications such as Uber are the best examples of Location-based services. The application detects your current location and decides the cab nearby based on distance and sends that cab to you so that you can reach your required location. The entire concept of this application works on location - the location of the user, location of the cab, the destination and the way to reach the destination.
Location-based advertising (LBA) - These services are based on the fact that we carry our mobile phones wherever we go and based on our locations and stores in the neighborhood, we get advertisements about the same.

Example: Imagine you are in your village and your phone shows an advertisement about a clothing brand that is not in the near vicinity then it is very likely that you will ignore that advertisement. But if you are in a shopping mall where there is a store of this brand, and the ad appears on your phone then it is very likely that you will pay attention to that advertisement and may even visit the store.

## III. TYPES OF CONTEXT

Abowd et al. define context as "any information useful to characterize the situation of an entity (e.g., a user or an item) that can affect the way users interact with systems" [1]

Raw data usually consists of a lot of entries that do not make sense unless we consider the situational parameters. This is where context helps us evaluate that raw data. Contexts are often inter-related. We can use contexts of time or user activities along with location because each context adds significant value to the final decision outcome.

**Context Types -**

**1. Individual -** This type of context refers to the information that is recorded from various independent users. This category can be further classified into a few sub-categories. Natural context refers to the information that can occur naturally (e.g., rain information, climate information). Human context refers to user activities and choices (e.g., Movie genre choice). Artificial context refers to entities that occur from human behavior.
Example - The temperature of a certain area can be used as a context while recommending him what to buy in many E-commerce applications. If the temperature of the place where the user is residing currently is around 10°C, then recommending him sweaters and jackets would be a great option for E-commerce.
**2. Location -** The location where the activity is being performed by the user relates to this type of context. (e.g., the place where a person lives, the place where a person shops). This type of context can be further classified into physical or virtual locations.
Example - This type of context has been the most widely used. The restaurant to visit next based on the current location is a type of location context application.
**3. Time -** This type of context generally contains information about time like current time, the present day, the week, the month, the year, etc. Time context can also be classified into two categories: definite and indefinite time context.
Example - Imagine a user wants to visit a park for some leisure time and looks for recommendations about the same but the application suggests some places which are closed at the time the user wants to visit. Hence the current time helps while predicting places to visit.
**4. Activity -** This type of context refers to the activity or task performed by the user. (E.g.: Driving a Car, Watching a movie)
Example - While driving a car people usually listen to rock music and while providing the context of activity as driving the application can suggest some of the best rock music songs.
**5. Relational -** This type of context refers to the relationships between the users or entities in various situations. (relations or associations between various users)
Example - In applications such as social media where the relationship between two users can be easily identified based on what they like, their actions, etc. Such information can be used in predicting a user when such similar information has been available about the person the user is related to.

## IV. GENERAL ARCHITECTURE OF CONTEXT-AWARE SYSTEMS

In any context-aware system the first part of the system is to generate context according to the use case of the application. In these applications location, time, weather, etc can be used as the context individually or any other form combining two or more contexts. To generate these methods different methods can be used. For weather or social media sentiment context there are many APIs that can be used. A location-based context can be generated from the GPS on your phone. Personal information type of context such as age can be taken from the application when the user first registers. Once we have all the context required for our application we feed it to the prediction system. Due to the advances in Machine Learning, it is possible to get relevant conclusions from the various sets of generated data. These algorithms can be used for predictions, recommendations, clustering and mining user patterns. Clustering algorithms can be used to cluster users into groups based on their similarities and suggestions to a certain user can be made based on the users in his group. Mining user pattern algorithms take into account the entire user history while using the application and draw certain conclusions based on that data. The prediction system based on the values of the context gives us dynamic recommendations. These recommendations change as soon as any of the context values are changed and hence they are dynamic.

When the user chooses a certain recommendation over the other then that can be taken into consideration in future situations.

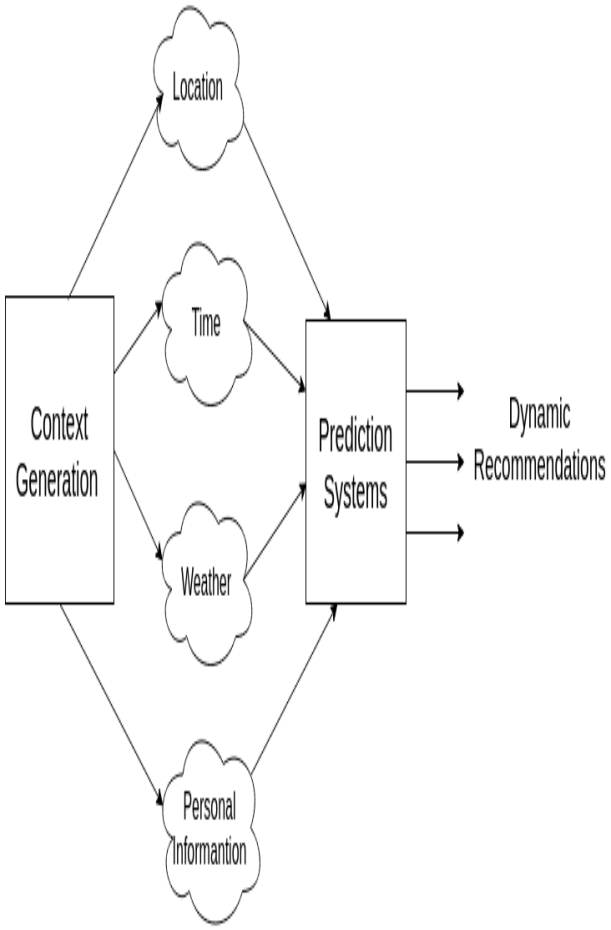


**Fig. 1.General Architecture of Context Aware Systems**

## V. LITERATURE SURVEY

1. Meehan et al. [2] in their work states that traditionally all the tourism-related applications used to take only the location as a context which then used to give results based on only distances. But this paper suggests that all available contextual information should be taken into consideration while making decisions on what location a user must visit. The paper then considers five primary contexts - location, weather, time, sentiment, and user preferences.

The location context is essential to the user as the user will want information and directions for other locations or points of interest. The time context is vital as it checks whether the point of interest is not closed before suggesting it to the user. The weather context takes into account whether the weather of the point of interest is favorable or not. Social media sentiment takes into account whether other people's opinion about the point of interest or not. User preference generally includes information like age, gender, relationship status, and the number of children, etc.

A hybrid system called VISIT (Virtual Intelligent System for Informing Tourists) is then created, which has intelligent decision making based on techniques such as artificial neural networks, fuzzy logic, and principal component analysis.

2. Lin et al. [3] in their paper aim to motivate people to be physically active by providing recommending messages on their phones by taking into account various types of contexts. This application called Motivate takes into account the location, time, weather, user agenda, and profile of the user as the context.

This system consists of service, web application, and Mobile API, which communicates with the mobile application. The web application is used by the users to edit their profile and agenda.

There is an Advisor service in the Motivate service that takes into account all these contexts and finds advice in the advice database based on the suitability for the given situation. There is a set of IF-THEN rules which suggest the advice that must be specified for the various constraints. There are 34 different advices and 20 different activities based on various contexts. These constraints are the various contexts defined earlier.

3. Traditional recommendation systems use only user preferences in the form of ratings. Otebolaku et al. in their paper [4] presents a context aware media recommendation system architecture that takes context information such as user activities, time, device, activities, location, and network capabilities.

The components for the context-aware media recommendation are media content profiling management, context and activity management, contextual user profiling service, media item recommendation service, and media item presentation adaptation. The implementation presented in the paper can be implemented on any platform and is thus platform-neutral. It can be implemented as a client-server system with client services running on mobile devices. The architecture developed is generic to handle various types of online-based media content, and feasibility is demonstrated with a context-aware mobile movie recommendation application.

4. Mohamed et al. in their approach [5] designed a context-aware recommender system which recommends places to users based on the time of the day, the user's mood, and the current weather. The system determines the time and weather in the user's location. It then recommends places based on the context state in the user's location. It takes into consideration the user's mood while recommending him places. The recommendation of places takes into account what places other users have visited in similar context situations.

A new algorithm called Context-Aware Genetic Recommender System (CAGRS) was proposed in this paper. The algorithm consists of five modules - collecting stay points, clustering these points, finding popular places in the clusters formed, getting weather and time in each stay point and getting the frequency of these parameters in each cluster. The system takes into account the user's locations and mood and finds weather and time accordingly. The system uses Genetic Algorithm that rates in each place as stated by to various context conditions and for each user.

5. The paper by Son et al. [6] aims at recommending news articles to a user based on their interests. It proposes Explicit Localized Semantic Analysis (ELSA) which is and ESA-based topical representation of documents. It highlights the importance of the current location of a user as a user context. ELSA measures how relevant a news article is to a particular location.

**Table- I: Summary Table**

| Paper | Context | Algo/Tech | Dataset | Performance | Observation |
|---|---|---|---|---|---|
| [2] | location, weather, time, sentiment and user preferences | A system called VISIT is proposed in the paper. This technique utilizes intelligent decision making by using techniques such as PCA, Neural Networks and Fuzzy logic | Weather data is provided by WorldWeatherOnlineAPI. Sentiment data is provided by Alchemy API. | The proposed system is compared to other Tour Applications based on the factors - location, time, weather, POI sentiment, personalization, scalable and device independence. There is no other model apart from the one mentioned in paper which takes into consideration every factor | The paper gives reasons to why every context mentioned is important in the decision making process |
| [3] | location, time, weather, user agenda and profile | Motivate software system based on Ruby on Rails web framework. The system comprises of service(to give recommendation), web application(to change user's personal agenda) and API's that communicate with the mobile application | The location is created by adding geographic information given by OpenStreetMap. Weather history data is provided by the Weather Underground site. | A user study of 6 people was conducted to evaluation purposes. The split of messages sent in the morning, afternoon and evening were 45.3%, 25% and 29.6%. Of the 464 total messages, 434 responses were given by the users of which 50% were positive responses | The most sent messages were taking a break during work (14.5%) and taking the stairs when arriving or leaving work (10.5%). The reasons for negative response were "busy at the moment, have no time" (24.5%), "already have other plans" (19.8%) and "feel no need to do the activities" (17%). Other reasons were "bad weather", "I feel tired", "It's not feasible" and "I don't feel like it" |
| [4] | User preferences, activities, time, location, device and network capabilities | Context acquisition, recognition, representation, using MPEG-21 and ontology model, MPEG-7 | Media metadata from online media repositories | A context-aware movie recommendation application is developed to demonstrate the feasibility of the system | The architecture developed can handle various online-based media contents |
| [5] | the current weather, the time, location and the user's mood | CAGRS algorithm is proposed which consists of five modules. The system uses Genetic Algorithm that rates each place | The stay points have been collected by Microsoft Research Asia's Geolife project. API's are used to collect weather and time data | Mean Absolute Error was calculated between real data and experimental data. Also the results given from Genetic Algorithm using Gamma function were compared with the resulted data from Distributional-Semantics Pre-filtering (DSPF) based on Matrix Factorization (MF) and K-Means clustering algorithm | Several graphs have been made of the results generated from Mean Absolute Error |
| [6] | location | ELSA (Explicit Localized Semantic Analysis) | Flickr Dataset | ELSA outperformed Bag of Words, Latent Dirichlet Allocation, Probabilistic Explicit Semantic Analysis and Explicit Semantic Analysis. | There is a 46.25% improvement for Rt10 of ELSA and NDCG@k was always higher than others irrespective of k |
| [7] | User profile and user context | Automatic Contexts Discovery, Automatic contextual mappings discovery, and Contextual Top K Neighbors | Standard log files of users | The two proposed design and recommender services successfully makes a decision to determine whether a candidate should be recommended the content or not | A set of personalized services are proposed that can improve Recommendation Services by introducing the notion of context |

Location representation in ELSA is done by mapping a set of geo-tagged documents for a location onto a topic space explicitly defined by Wikipedia concepts. Local topic distribution denotes the probability of a topic at a particular location. A dependency structure of local topics is first created by ELSA which is used for estimating the local topic distribution. The dependency structure is represented as a directed graph that is constructed using link information which is within Wikipedia articles. The paper goes on to compare ELSA against four methods: Bag-of-words (BOW), Latent Dirichlet Allocation (LDA), Explicit Semantic Analysis (ESA), and Probabilistic Explicit Semantic Analysis (PESA). The methods were evaluated against Rt10 and NDCG@k metrics, and results show ELSA outperforming all other methods.

6. Abbar et al. in their work [7] proposes a context-aware recommender system (CARS) based on both user profile and context. The work is based on Personalized Access Model (PAM), which is defined from work on data personalization. It states the two components of the architecture of context-aware RS.

Knowledge Acquisition process, which acquires and manages the knowledge CARS needs to process recommendations, and Personalized recommendation, which encompasses the actual RS operations.

The paper goes on to propose some personalization services which improve RS. Two design services, namely: Context Discovery and Contextualization. Two recommendation services, namely: Binding and Matching.
Context Discovery aims at learning from user log files. Contextualization checks for correlations within a given context between user profile elements and user feedback. Binding identifies user profile parts related to a given context at run-time. It is shown how these services can be combined to form CARS.

## VI. CONCLUSION

Thus we can conclude that the various types of contexts available to the systems always have a great effect on the quality of recommendations to the users. A system that takes the available contexts has a dynamic recommendation which is not provided by systems that do not use context because of the changing user needs. Many different contexts play different roles in different applications. But location is a context that is used most often because almost everyone has a smartphone and tracking user location based on smartphone and using it as context in systems is gaining much popularity and is the most researched area.

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