Context-Aware Proactive Personalization of Linear Audio Content

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ABSTRACT

How many times did you wish the radio programming was more aligned with your interests or current situation? How many times did you feel the need to change the channel because of a non-interesting content on your favorite station? Did you ever feel distracted by the audio programming in your car at a busy intersection? We present a platform for *proactive personalization of linear audio content* within a hybrid content radio framework. Hybrid content radio programming aims at enhancing the traditional broadcast radio experience and augmenting it with audio content related to the listener's context. It allows enrichment of the broadcaster's program schedule with context-aware, personalized audio content, with the goal of improving the users' listening experience, decreasing their propensity to channel-surf, and giving them more targeted content, such as local news, entertainment, music and also relevant advertisements. Differently from most of the popular commercial recommendation-based streaming music services, hybrid content radio systematically and automatically adds audio content to an existing, linear audio structure. More specifically, part of the linear content is *replaced*, in a proactive way, with *content relevant to the user's current context* – i.e., profile, emotional state, activity, geographical position, weather, or other factors contributing to the state of the listener. In addition to enabling functional enhancement of the radio experience, the presented framework also supports network resource optimization, allowing effective use of the broadcast channel and the Internet.

CCS Concepts

•Information systems → Recommender systems; Location based services; Multimedia streaming; Speech / audio search;

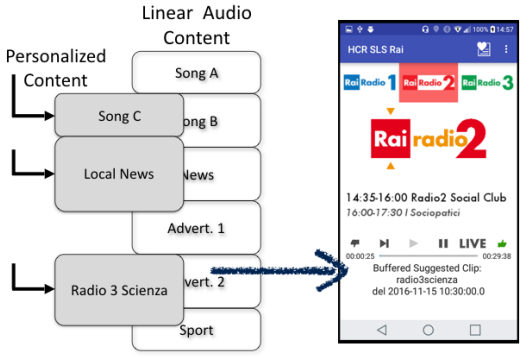

Figure 1: The hybrid content radio audio replacement concept, and a view of the prototype app playing the clip.

Keywords

Personalization; Recommender Systems; Context-based recommendations; Location-based services; Radio.

1. INTRODUCTION

We present a novel platform for *context-aware proactive personalization of linear audio content* within a hybrid content radio framework, so we specifically focus on audio content delivery. The Proactive Personalyzed Hybrid Content Radio (or PPHCR) system we present is part of the evolution of traditional linear radio, as described at the International Broadcasting Convention in 2015 [6] and in [7, 10]. PPHCR is based on the live radio streams and associated metadata from Rai, the Italian Public Service Media Company. Beside dealing with all the intermediate scenarios where the broadcaster provides a linear programming, hybrid content radio recommends enriching and context-based online content.

1.1 Context-Driven Content-Delivery in Hybrid Content Radio

Hybrid content radio aims at making linear broadcast radio more flexible, allowing seamless replacement of parts of the broadcast audio content with relevant audio content mined from recent podcasts and content archives. The basic metadata descriptions enabling this service come from the ETSI Standards created by the RadioDNS Project, see [9]. Figure 1 illustrates the content replacement concept, with

Figure 2: Audio content is recommended following contextual information, such as listener's position and route. When the user's car starts moving, the system predicts a travel duration ΔT, and tries to allocate the most relevant content for the available time ΔT, recommending media items A, B, C, D. Item B is also relevant to location L_B the user will reach.

the user interface of the prototype client app.

Context-aware recommender systems have been subject to increasing attention in the last few years, see [2]. Some studies specifically focus on location awareness, specially those related to the mobile context, see for example [14] and [11].

The proposed PPHCR prototype takes advantage of a novel **proactive recommender system** (PRS), see [5, 13], capable of deciding the time of the recommendation delivery, as described in Section 1.2. The recommender system provides contextually-relevant alternative audio content that will replace part of the broadcast content thus increasing the user's satisfaction and decreasing her tendency to switch channels. Using linear radio as the basic building block for personalized radio has two main advantages:

- the relevance of the content for the listeners increases, enriching their experience, while they keep on listening their favorite radio station
- the efficiency of content delivery can be optimized, if the device allows using a broadcast technology to receive the audio from the broadcast channel

The core novelty of the proposed service, compared to other existing approaches, consists in the joint usage of linear radio personalization and in the type of proactive context-based recommendations, based on the listener's location, movement and preferences. PPHCR creates personalized audio content suggestions accounting for uncertainties in the mobile user's future path as well as driving conditions during the scheduling and delivery of a highly relevant and enjoyable, and yet non-distracting hybrid-audio content.

Figure 2 illustrates an example of proactive recommendation for a driver: the system predicts the route and travel duration and maximizes the relevance of the recommended media items, based on a combination of learned user preferences and geographic relevance of the content. As illustrated in this example, effective delivery of personalized linear radio, with context-based content recommendations, requires to solve the problem of integrating linear schedule timings, spatial information and listeners' preferences, making the solution innovative with respect to existing proposals [4].

1.2 System Description

The functionality of the system relies on the server architecture shown in Figure 3 and on the client PPCHR app

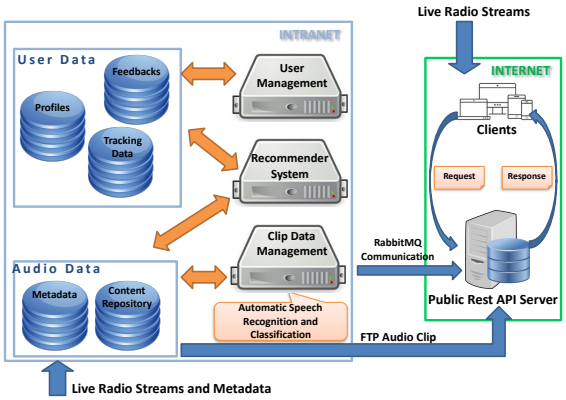

Figure 3: Simplified architecture of the context-aware personalized radio system

that provides the user interface and collects data relevant to discover the context. The content server is the integration of several components cooperating to offer a real-time, personalized radio service. Radio Rai, the radio division of Rai Public Service Media Company, directly provides 10 live 96kbps audio streams [1], the editorial version of more than 100 podcasts created every day and the associated schedule metadata are used to populate the **content repository** and the **metadata DB**. The podcasts are classified by the **clip data management** component according to their categories. News programs, including large parts of speech, are analyzed using an automatic speech recognizer trained with the Italian language. The extracted text is then classified with a Bayesian classifier trained with a set of news, according to a set of 30 categories spacing from art to culture, music, economics.

User data are organized by the **user management** component. The user's demographic details are stored in the **profiles DB**. The **feedbacks DB** hosts content navigation logs sent by the listener's app together with the implicit or explicit rating given by the user. The **tracking data DB** is a PostGIS based spatial DB with the listener's geographical information. The amount of GPS data arriving to the tracking data DB requires to periodically process and simplify them, extracting a compact, discrete model which describes destination, trajectory, speed, frequency, time of the day and *complexity*. Major *staying points* on the driving paths are calculated using a density based location clustering [8] and complexity is calculated analysing the trajectory simplified using the Ramer-Douglas-Peucker algorithm (RDP).

Contextually relevant linear content recommendations are provided by the **recommender system** component using both user and audio data clusters. For each user the recommender filters a candidate set of media items using content-based relevance based on past listener's feedbacks. Then a compound relevance score is calculated through weighted combination of the content-based relevance and the context-based relevance (location, trajectory, speed and time information). The recommender system then uses the this score to identify the recommendation set of content to be delivered to the listener according to a relevance objective function and temporal scheduling and presentation constraints, taking into account driving conditions as well as driver's pro-

jected distraction levels at intersections and roundabouts at user's projected driving path.

1.3 Client Android App

The client PPHCR app, whose interface is shown on the right side of Figure 1, has been implemented on Android mobile OS. The listener can choose one of the live radio services, change service, pause, or skip content. While the user is listening to the service, a positive implicit feedback is periodically sent for that audio content. In contrast, each skip action generates a negative feedback. The app synchronizes metadata and implements buffering and synchronization to ensure that the selected live audio is seamlessly replaced by the recommended clips.

The controls are shown in Figure 1: the user can manually give a feedback, skip current program or navigate the favorite media items.

2. DEMONSTRATION OUTLINE

The demonstration is centered on the personalization of live radio for a listener on the move, in her car. The movement can be real or simulated using an Android third party app providing fake locations (see for example [12]). The personalization works in a proactive way, using a proactive recommender system as described in [13, 3, 5]. The PPHCR App collects and sends to the user management module user's preference data and the GPS locations of the moving listener, allowing to predict the trajectory she's following. Using the listener's feedback and the routes collected when she moves, the system learns to suggest and play content independently from an explicit user action. The key tasks enabled by the prototype are the following:

implicit and explicit user feedback the user can give implicit feedback to the content skipping it, or explicit feedback with the like/dislike buttons

manual skip users can skip live programs and, thanks to buffering synchronized with program schedule metadata, seamlessly replace them with recommended content

proactive recommendations destination, trajectory, speed and available time predictions allow to proactively suggest a list of media items; geographic information is also used to refine recommendations

editorial recommendations injection the editor can selectively choose and inject recommended audio content to specific users

2.1 Demonstration Scenarios

We present two demonstration scenarios: in the first one, the content change is manually triggered by the listener; in the second, the enrichment of the audio content is triggered by a real-time change in the listener's context – more specifically, listener's movement in space.

2.1.1 *Manual Program Change*

While listening to linear radio, from a broadcast channel such as analog FM or digital DAB+, or from the Internet, the user can sometimes wish to listen different content. Greg is passionate about technology and economy, often listening to programs on this topic during the day. This morning there is an endless discussion about football results on his

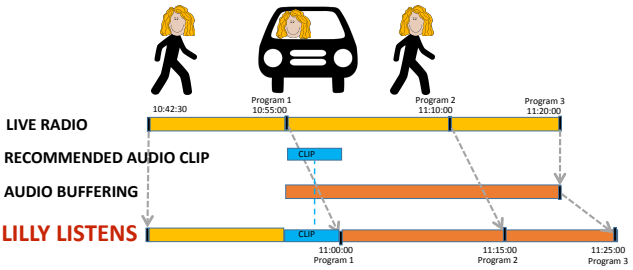

Figure 4: The app recommends an audio clip while Lilly is driving to work (timeline).

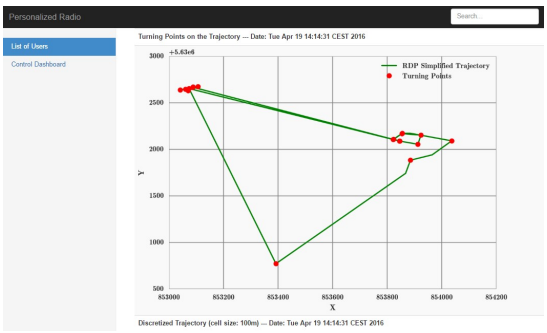

Figure 5: Control Dashboard: map with the last listener's movements

favorite radio channel. He is about to zap channel, but now his radio app allows him to *skip* the live program and surf a list of suggested audio clips. After two skips Greg reaches one of his favorite programs: "Wikiradio".

2.1.2 *Contextual Proactive Recommendation*

Lilly is a young researcher and an appreciated amateur chef. She always tries new recipes and lets her colleagues taste the results. Lilly also likes listening radio while she drives from home to work in the morning and from work to home in the evening. Sometimes music, more often radio talks and discussions on several subjects, especially to those related to food, recipes and cookery. In the past it was difficult to find an interesting program. She tried to record audio programs in the evening for the morning, but it was tricky. This morning is different: her radio app had an update some weeks ago. After she has been driving for some minutes, the PPHCR App *automatically plays* the last news and, after this, an audio clip from "Decanter" program, discussing the differences between French Champagne, Spanish Cava and Italian Prosecco. After that she is pleased to hear the jokes of the time shifted live "The rabbit's roar": the program began 20 minutes ago, but the app can still smoothly present it after "Decanter". She listens, pleased and interested, forgetting the skip button. Figure 4 shows the time-line of the personalization process for Lilly. The suggestions are based on her previous skip history and the knowledge of the context.

2.2 Control Dashboard

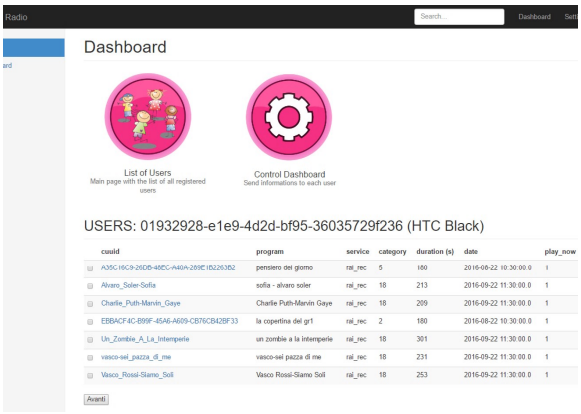

Figure 6: Control Dashboard: list of recommendations to send to a specified user

During the demonstration a web-based control dashboard will be used to visualize the users' behavior during the experimentation. The website visualizes the user's past trajectories, content preference, and the details of the recommendation process (see Figure 5). The dashboard also allows to manual injection of recommendations help test recommendations (Figure 6).

3. CONCLUSIONS AND FUTURE WORK

We presented a Proactive Personalized Hybrid Radio system, capable of enhancing the linear radio stream, proactively proposing targeted audio content. The recommended audio items list and the time to show it is generated using the listener's past preferences and the prediction of her current movement. The key contributions are the location and movement information awareness to decide both the time and items to recommend, and the integration of live broadcast and personalized audio content. The system allows a listener-centric radio experience, with the possibility of explicit content skips and proactive audio content recommendations, while preserving the appeal and sense of connection between listeners of traditional broadcast radio. During the demonstration, the audience will be able to observe both the user experience (through the client mobile app) as well as the data-flow and recommendation generation process (through the web based control dashboard).

For the future, we are planning to estimate the geographic relevance of audio items available in the archives. This operation involves the analysis of informative and entertainment content as well as advertisements, validated by a user trial. Furthermore, we plan to create recommendations list taking into account richer contexts: time, activity, weather, and the ensemble effect of the recommendations list.

4. ACKNOWLEDGMENTS

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5. REFERENCES

[1] Radio rai. http://www.radio.rai.it. Accessed: 2016-11-15.

[2] G. Adomavicius and A. Tuzhilin. Context-aware recommender systems. In *Recommender systems handbook*, pages 191–226. Springer, 2015.

[3] J. I. Árnason, J. Jepsen, A. Koudal, M. R. Schmidt, and S. Serafin. Volvo intelligent news: A context aware multi modal proactive recommender system for in-vehicle use. *Pervasive and Mobile Computing*, 14:95 – 111, 2014. Special Issue on The Social Car: Socially-inspired Mechanisms for Future Mobility Services.

[4] M. Braunhofer, M. Kaminskas, and F. Ricci. Location-aware music recommendation. *International Journal of Multimedia Information Retrieval*, 2(1):31–44, 2013.

[5] M. Braunhofer, F. Ricci, B. Lamche, and W. Wörndl. A context-aware model for proactive recommender systems in the tourism domain. In *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct*, MobileHCI '15, pages 1070–1075, New York, NY, USA, 2015. ACM.

[6] P. Casagranda, A. Erk, S. O'Halpin, D. Born, and W. Huijten. A framework for a context-based hybrid content radio. In *International Broadcasting Convention (IBC)*, 2015.

[7] P. Casagranda, M. L. Sapino, and K. S. Candan. Audio assisted group detection using smartphones. In *Multimedia & Expo Workshops (ICMEW), 2015 IEEE International Conference on*, pages 1–6. IEEE, 2015.

[8] M. Ester, H.-P. Kriegel, J. Sander, and X. Xu. A density-based algorithm for discovering clusters in large spatial databases with noise. In *Proceedings of the Second International Conference on Knowledge Discovery and Data Mining*, pages 226–231, 1996.

[9] ETSI. Ts 103 270, RadioDNS hybrid radio; hybrid lookup for radio services, January 2015. http://www.etsi.org/deliver/etsi_ts/103200_103299/103270/01.01.01_60/ts_103270v010101p.pdf.

[10] S. Metta, P. Casagranda, A. Messina, M. Montagnuolo, and F. Russo. Leveraging MPEG-21 user description for interoperable recommender systems. In *Proceedings of the 31st Annual ACM Symposium on Applied Computing*, pages 1072–1074. ACM, April 2016.

[11] M. Sarwat, J. J. Levandoski, A. Eldawy, and M. F. Mokbel. LARS*: An efficient and scalable location-aware recommender system. *IEEE Transactions on Knowledge and Data Engineering*, 26(6):1384–1399, 2014.

[12] D. Villeneuve. Lockito. https://play.google.com/store/apps/details?id=fr.dvilleneuve.lockito. Accessed: 2016-11-15.

[13] W. Woerndl, J. Huebner, R. Bader, and D. Gallego-Vico. A model for proactivity in mobile, context-aware recommender systems. In *Proceedings of the fifth ACM conference on Recommender systems*, pages 273–276. ACM, 2011.

[14] H. Yin, Y. Sun, B. Cui, Z. Hu, and L. Chen. LCARS: a location-content-aware recommender system. In *Proceedings of the 19th ACM SIGKDD international conference on Knowledge discovery and data mining*, pages 221–229. ACM, 2013.