

Life-Logging for Healthcare Proactive Advisory Systems

Thai Son Nguyen¹, Francesco Ricci¹, Floriano Zini¹, and Marcello Granconato²

¹ Free University of Bozen-Bolzano, Faculty of Computer Science
Piazza Domenicani 3, 39100 Bolzano, Italy
thaison.ngn@gmail.com, fricci@unibz.it, floriano.zini@unibz.it
² Stallergenes Italia
marcello.granconato@gmail.com

Abstract. Proactive Advisory Systems (PASs) are an extension of Recommender Systems (RSs) that push suggestions and advice even if not explicitly requested, while adapting such advice to the specific contextual situation of the user. They support the user in decision-making processes more complex than those considered by traditional RSs. In this paper, we illustrate the first results of the *LiloPAS* research project, targeted to the design, development, and evaluation of PASs for healthcare. We present *Smart Allergy Taming*, a prototype mobile PAS for allergic patients, and give the results of its evaluation.

Keywords: proactive advisory systems, life-logging, user modeling, healthcare.

1 Introduction

Proactive Advisory Systems (PASs) [1, 14] are decision and task support systems that take the initiative to timely suggest actions and help users to make decisions. PASs require the extension of the traditional computational and interaction model adopted in Recommender Systems (RSs). Other than providing recommendation when explicitly requested, PASs should also be able to proactively push or recall suggestions and advice, while adapting such advice to the specific contextual situation of the user. In addition, PASs should support user's decision-making processes that are generally more complex and risky than those supported by traditional RSs, which are mostly focused on suggesting simple items such as movies to watch or products to purchase.

We are interested in implementing PASs for healthcare as mobile applications. In particular, our case study application supports patients suffering from allergic rhinitis in the proper management of their immunotherapy and in the adoption of behaviors that reduce the allergy impact on their quality of life. Allergic rhinitis is one of the most common chronic diseases in the world and affects up to 30% of people [9]. Allergen immunotherapy offers to patients more than symptomatic treatments, as its benefits persist several years after discontinuation of the treatment. However, immunotherapy requires a very careful management,

as the treatment often needs to be administrated for a period of 3–5 years to be effective, and the patients need to strictly adhere to a precise schedule of medication intakes. Patients suffering from allergic rhinitis could take advantage of a mobile PAS in several ways. For example: receiving notifications that improve the adherence to the treatment schedule; or being suggested actions that reduce the allergy impact, such as closing the car windows when they are driving in an area with high concentration of pollens to which they are allergic.

The development of PASs brings new research challenges. In order to be effective in the proactive support of the user, as allergic patients require, PASs should be able to continuously monitor the user’s activities and environment and build, automatically or with minimal user intervention, a meaningful user model. The model could capture, for example, that the allergic patient is keen on physical exercise in the open. The learned model must then be exploited to provide relevant advice fired by the current users situational context. For example, the sporty allergic patient could be advised to exercise in the open when the concentration of the pollen to which she is allergic is low.

The goal of the *LiloPAS* project (*Life-logging for Proactive Advisory Systems*) is to address the above mentioned research challenges and investigate techniques and algorithms for healthcare PASs, to be embedded in a mobile prototype that provides advice to patients affected by allergic rhinitis. As a first step towards a fully operational PAS, we designed and implemented *Smart Allergy Taming*, a proof-of-concept we used to quickly collect feedback useful to drive the further stages of the project.

In the rest of this paper, we briefly give an account of the background research on which our project is based and describe the design and the first evaluation of *Smart Allergy Taming*.

2 State of the Art

Personalized ehealth [10], and in particular the field of mobile-phone-based personalized health interventions, is receiving increasing attention. In their rich review [7], the authors survey systems developed in health science and human-computer interaction (HCI) and highlight the importance of understanding the patient context in order to improve the intervention strategies.

Previous research on life-logging focused on the acquisition, elaboration, and access of users’ life data. Some researches concentrated on the development of toolkits that help to automatically acquire users’ data, either capturing desktop activities [5], or logging from mobile phone sensors and applications [3, 11], or doing context-triggered sampling of experiences by directly asking users [3]. Other researches [2, 8] investigated how to elaborate the acquired data so that meaningful higher-level context can be discovered. How the users can access their logs is addressed in [2, 13].

Nowadays there is an increasing number of commercial wearable trackers³, equipped with sophisticated sensors that record data such as steps, heart rate,

³ See <http://www.pcmag.com/article2/0,2817,2404445,00.asp> for some examples.

burned calories, or how many times one wakes up during the night. Wearable trackers can be exploited, in addition to smartphones, as life-logging devices.

Finally, it is worth mentioning that life-logging research has its roots in HCI. Users need to interact with their (mobile) life-logging applications, which must be appealing and usable. For example, in [4] the authors evaluate various user data input interfaces for a mobile health application that collects data relevant to the treatment of insomnia.

3 Smart Allergy Taming

Smart Allergy Taming is a mobile PAS for patients suffering from allergic rhinitis. The functionalities of the prototype were designed with the cooperation of experts of the partner company Stallergenes Italia⁴. They were selected to cover the main aspects (support for a correct intake of the treatment and monitoring of the impact of the treatment on the patients' health) that the expert hypothesized as important for a mobile system supporting a successful sublingual immunotherapy. The function of *Smart Allergy Taming* is:

1. Digital agenda of the activities the allergic patients have to do to correctly adhere to their immunotherapy;
2. Proactive reminders of the tasks in the agenda, e.g., treatment intake, fill out of health surveys (Figure 1-a);
3. Simple proactive tips about how to manage and keep the vials containing the medicines for the immunotherapy;
4. Timer that helps the patients when they take the dose of medicine, which has to stay two minutes under the tongue;
5. Indicators for the current and recent level of control of the allergy, and for the impact of the allergy symptoms on the patients' quality of life (Figure 1-b);
6. Log of the symptoms experienced by the patients and their impact on the patients' quality of life, by means of digital survey administrated every week (Figure 1-c); the collected information is processed to calculate the indicators mentioned above.

In addition to the above mentioned functionalities, we implemented in *Smart Allergy Taming* a simple mechanism, showing predicted values for the user replies to the various items in the questionnaire. We conjectured that such a mechanism could help the patients better remember the intensity of symptoms and their impact on the daily life in the past week. In this way, we wanted to heal the well-known discrepancy between experienced well-being (more precise) and remembered well-being (influenced by memory and personality biases) [6], that can limit the reliability of the health report filled by the patients. The system weekly collects the user's replies to the various questions, hence building time

⁴ Stallergenes Italia (www.stallergenes.it) is a leading company for the production of treatments for allergy.



Fig. 1. Some function of *Smart Allergy Taming* (Italian version): (a) Reminder; (b) Indicators; (c) Survey.

series, and then predicts the next week user input, offering it as default value in the questionnaire. The predictions are calculated using exponential smoothing⁵, so that the recent answers have a greater weight than the older ones.

3.1 Evaluation

We are evaluating *Smart Allergy Taming* with the goal to acquire feedback, in the early stage of the project, on the effectiveness of the implemented function, on the usability of our design, and on the usefulness of the remembering support mechanism we have developed.

We conducted a pilot test involving two domain experts from Stallergenes (different from those involved in the design of the prototype), one HCI expert, and four computer science students of our University. We decided not to involve patients in this phase to speed up the evaluation, as recruiting patients would have delayed the pilot. The users were given a paper sheet describing the functions of the system and a typical usage scenario, they were asked to execute. The task consisted in reporting the immunotherapy and other medicines intake, simulating the immunotherapy intake, filling the weekly health survey, and visualizing the allergy control and quality of life indicators.

At the end of the task the users were asked the *Single Ease Question (SEQ)*, a 7-points rating scale to assess how difficult a user finds a task, with 1 indicating

⁵ <http://www.itl.nist.gov/div898/handbook/pmc/section4/pmc43.htm>.

“very difficult” and 7 indicating “very easy” [12]. In addition, they were asked to indicate up to 5 usability problems they encountered and up to 5 liked features of the application.

The average SEQ score of our sample was 5.43 with a standard deviation of 0.53. The 98% confidence interval for the score, calculated using the t -distribution, ranges from 4.80 to 6.06. We compared our result with the average SEQ score across over 200 tasks performed by 5000 users (included in a reference benchmark), which hovers between about 4.8 and 5.1⁶. Even though our sample contains a small number of subjects, we can conclude that *Smart Allergy Taming* easiness of use is on a par with the benchmark.

By examining the users’ answers, we discovered that they generally liked the system function. Some users appreciated the tips and indicated that additional contextual advice about how to manage the disease could be useful. The users also appreciated the look and feel of the application, especially the graphical elements. Most of them considered the navigation through the various views as easy and intuitive. Some users also highlighted usability problems such as minor navigation issues between application views, colors and contrast not suitable for people with sight problems, and audio notifications not always audible. In summary, the pilot test demonstrated the goodness of the system functionalities and the design of the GUI.

We are currently improving *Smart Allergy Taming* in order to eliminate the usability problems highlighted by the pilot test. The improved application will be evaluated in a between-subjects experiment involving real allergic patients. The objective of the experiment is to assess the usefulness of our memory support mechanism to fill in the survey, comparing a version of *Smart Allergy Taming* embedding the support mechanism with a version without support. The metric we are going to use in the evaluation is the accuracy of the reported intensity of symptoms and their reported impact on the patient’s quality of life. Our hypothesis is that the memory support mechanism produces a higher accuracy. In order to assess our hypothesis, we plan to use a digital diary that the patients will fill every day of the experiment. In the diary they will indicate the intensity (on a scale from 1 to 4) of the symptoms that have experienced in the current day and which was the impact of these symptoms (on a scale from 1 to 4) on various aspects of their daily life. The answers recorded in the diary will be averaged in order to produce the gold standard to be compared with the answers given in the weekly survey using the two versions of the mobile application.

4 Conclusions

Smart Allergy Taming is a PAS prototype that was developed to investigate which functionalities are suitable for supporting allergic patients in the the execution of their immunotherapy, to early evaluate the design of a GUI for these functionalities, and to evaluate a memory support mechanism for manual logging of the health status of the patients. The results of the pilot test we have

⁶ <http://www.measuringusability.com/blog/seq10.php>.

conducted indicate that the selected functions the GUI are appropriate. We are currently assessing the memory support mechanism. The results of the evaluation of *Smart Allergy Taming* will drive the further stages of the *LiloPAS* project.

References

1. H Al Tair, MJ Zemerly, M Al-Qutayri, and M Leida. Architecture for context-aware pro-active recommender system. *International Journal Multimedia and Image Processing (IJMIP)*, 2(1/2):15–133, 2012.
2. Petros Belimpasakis, Kimmo Roimela, and Yu You. Experience explorer: a life-logging platform based on mobile context collection. In *Next Generation Mobile Applications, Services and Technologies, 2009. NGMAST'09. Third International Conference on*, pages 77–82. IEEE, 2009.
3. Jon Froehlich, Mike Y Chen, Sunny Consolvo, Beverly Harrison, and James A Landay. Myexperience: a system for in situ tracing and capturing of user feedback on mobile phones. In *Proceedings of the 5th international conference on Mobile systems, applications and services*, pages 57–70. ACM, 2007.
4. Daniel Gartenberg, Ross Thornton, Mortazavi Masood, Dustin Pfannenstiel, Daniel Taylor, and Raja Parasuraman. Collecting health-related data on the smart phone: mental models, cost of collection, and perceived benefit of feedback. *Personal and ubiquitous computing*, 17(3):561–570, 2013.
5. Jim Gemmell, Gordon Bell, and Roger Lueder. Mylifebits: a personal database for everything. *Communications of the ACM*, 49(1):88–95, 2006.
6. Daniel Kahneman and Jason Riis. Living, and thinking about it: Two perspectives on life. *The science of well-being*, pages 285–304, 2005.
7. Predrag Klasnja and Wanda Pratt. Healthcare in the pocket: Mapping the space of mobile-phone health interventions. *Journal of biomedical informatics*, 45(1):184–198, 2012.
8. Henar Martín, Ana M Bernardos, Josué Iglesias, and José R Casar. Activity logging using lightweight classification techniques in mobile devices. *Personal and ubiquitous computing*, 17(4):675–695, 2013.
9. Ruby Pawankar, GW Canonica, ST Holgate, and RF Lockey. *WAO white book on allergy*. Milwaukee, WI: World Allergy Organization, 2011.
10. C. C. Y. Poon, M. D. Wang, P. Bonato, and D. A. Fenstermacher. Editorial: Special issue on health informatics and personalized medicine. *Biomedical Engineering, IEEE Transactions on*, 60(1):143–146, 2013.
11. Reza Rawassizadeh, Martin Tomitsch, Katarzyna Wac, and A Min Tjoa. Ubiqllog: a generic mobile phone-based life-log framework. *Personal and ubiquitous computing*, 17(4):621–637, 2013.
12. Jeff Sauro and James R Lewis. *Quantifying the user experience: Practical statistics for user research*. Morgan Kaufmann, 2012.
13. Teruhiko Teraoka. Organization and exploration of heterogeneous personal data collected in daily life. *Human-centric Computing and Information Sciences*, 2(1):1–15, 2012.
14. Wolfgang Woerndl, Johannes Huebner, Roland Bader, and Daniel Gallego-Vico. A model for proactivity in mobile, context-aware recommender systems. In *Proceedings of the Fifth ACM Conference on Recommender Systems, RecSys '11*, pages 273–276, New York, NY, USA, 2011. ACM.