Modeling User Interface Adaptation for Customer-Experience Optimization

Christian Märtin, Christian Herdin, and Bärbel Bissinger
Augsburg University of Applied Sciences
Faculty of Computer Science
Augsburg, Germany
{Christian.Maertin, Christian.Herdin}@hs-augsburg.de; baerbelbissinger@web.de

***Abstract*—The customer journey in digital marketing defines several touch points, where interested users can directly interact with an e-business platform. In order to convert a user into a buyer, persona-based a priori adaptations of the user interface can be combined with dynamic adaptations at runtime with the goal to optimize individual customer experience and guide task accomplishment. This paper examines customer experience optimization for scenarios from a cosmetics industry e-business portal with the SitAdapt 2.0 system. Dynamic adaptations are triggered by situation rules based on the continuous analysis of the users' varying cognitive and emotional situations during a session. The model-based adaptation process exploits models and patterns for the rapid generation of user interface modifications.**

Keywords—customer journey; user experience; customer experience; situation analytics; situation rules; emotion recognition; eye-tracking; HCI-patterns

I. Introduction and Related Work

Digitalization in marketing can be seen as a straightforward approach to designing and implementing IT-based solutions for the generic steps of the customer journey. A customer journey is a customer's interaction at several touch points with a service or several services of one or more service providers in order to achieve a specific goal [9]. More focused on purchasing a product, the customer journey can be defined as an iterative process that includes touch point based interactions with a provider or a business during a pre-purchase, a purchase, and a post-purchase phase [13]. The journey could include experiences from earlier purchases and affect future purchases. In this view no fixed a priori purchase goal is necessary, but the service provider would try to arouse the interest of potential customers in the pre-purchase phase. At all touch points between the provider and the customer, one has to distinguish between the customer view and the provider view. It must be the provider's goal at every touch point, to create a situation that leads to optimum user experience (UX) for the potential customer.

UX during the customer journey is often described as customer experience. As an extract and synthesis of earlier research efforts customer experience can be seen as "a multidimensional construct" that focuses on "a customer's cognitive, emotional, behavioral, sensorial, and social" reactions to the offerings of a provider or a business "during the customer's entire purchase journey" [13].

With SitAdapt [14], [15] we have developed a software architecture for situation analytics and for integrating adaptive behavior into web- or app-based interactive applications. SitAdapt fulfills the requirements for automating essential parts of the customer experience optimization process as well as for various other domains from medical monitoring to driver assistance systems. Possible adaptations are modeled within the PaMGIS MBUID framework [5], [6]. They are triggered by situation rules and generated by activating and exploiting domain-dependent and independent HCI-patterns. In this paper we present our preliminary lab-based results for using the current implementation SitAdapt 2.0 with a new rule editor and an advanced situation interpreter within the e-commerce domain[1].

The paper includes the following main contributions:

- Discussion of a new model-based approach [17] for automating customer experience optimization
- Defining the potential for software adaptation [24], [12], [19], [20] based on situation analytics [3], context-awareness [22], and situation-awareness [7]
- Demonstrating the suitability of emotion recognition and bio-signal tracking for triggering user interface modifications [8], [19], [21], [23].
- Detailing the adaptation process and workflow for the e-business domain

The remainder of the paper is structured as follows:

Chapter II introduces the SitAdapt 2.0 system with its new rule editor. Chapter III first introduces possible adaptation features and defines example scenarios for generic and individual situations that are occurring in different phases of the customer journey when visiting a cosmetics business portal. Some of the possible SitAdapt 2.0 use-cases are demonstrated. After this, the chapter discusses the modeling and generation of adaptations. Chapter IV concludes the paper.

[1] Part of this work was carried out in cooperation with Dr. Grandel GmbH, Augsburg, Germany. We greatly acknowledge the opportunity to run the SitAdapt 2.0 tools and user tests on their enterprise e-business platform.

II. SITADAPT 2.0

The SitAdapt 2.0 runtime environment is integrated into the PaMGIS (Pattern-based Modeling and Generation of Interactive Systems) development framework. The framework allows for modeling and generating responsive behavior in the user interface and has now been enhanced towards dynamic adaptation by situation interpretation at runtime.

The architecture (Fig. 1) consists of the following parts:

- The *data interfaces* from the different devices (Tobii eye-tracker[2], Empatica wristband[3], Noldus Facereader[4], metadata from the application)

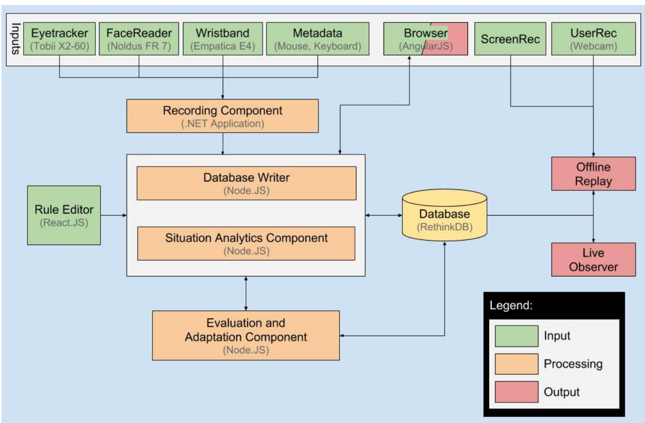

Fig. 1. SitAdapt 2.0 Architecture

- The *recording component* synchronizes the different input records with a timestamp, records the eye- and gaze-tracking signal of the user and tracks the emotional video facial expression as a combination of the six basic emotions (happy, sad, scared, disgusted, surprised, and angry) based on Ekman's model [4]. Other recorded data about the user are, e.g., age-range and gender [15]. The stress-level and other biometric data are recorded in real-time by a wristband. In addition, mouse movements and keyboard logs are protocolled [11].

- The *database writer* stores the data from the recording component and from the browser in the database in the form of discrete raw situations and manages the communication with the rule editor. Raw situations are generated at each tick of a predefined time frame varying from 1/60s to 1s.

- The *rule editor* allows the definition and modification of situation rules, e.g. for specifying the different user states (e.g. if a happy state is observed, it will only become relevant, if the state lasts more than five seconds and the grade of the emotion surpasses a certain activation level). For experimenting with rule heuristics and observing users we built a prototypical web application for long distance travel booking. In addition we used results from our cosmetics industry user study [1] for finding plausible situation rules. Fig. 2 shows the creation of a simple situation rule with two conditions and one action. In this case only a dialog with the user is created. However, situation rules can also activate HCI-patterns in the PaMGIS pattern repository. These patterns are exploited at runtime to generate user interface adaptations from predefined UI-, task-, or domain-model fragments.

- The *situation analytics component* analyzes the sequences of raw situations with their parameters varying over time and condenses them to a situation profile holding the most significant information about the currently applying situations. Typical situations can be described in the form of situation patterns. The situation analytics component matches the raw sequences to such situation patterns. A set of typical domain-dependent and independent situation patterns is available in the PaMGIS pattern repository. Such situation patterns can serve as templates for creating situation rules with the rule editor, where an action part with one or more actions is added. New situation patterns can be discovered by running offline data mining tools, e.g., RapidMiner[5], on the raw situation sequences recorded during multiple sessions.

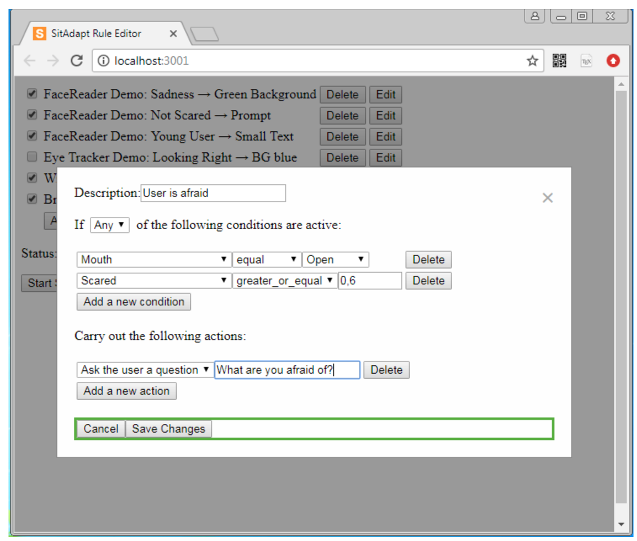

Fig. 2. SitAdapt 2.0 Rule Editor with an example rule exploiting visual emotions provided by Facereader

- The *evaluation and adaptation component* uses the situation profile provided by the situation analytics component to decide whether an adaptation of the user interface is meaningful and necessary at a specific moment. For this purpose the component evaluates given situation rules. Whether an adaptation is meaningful depends on the predefined purpose of the situation-aware target application. Goals to meet can range from successful marketing activities in e-business, e.g. having the user buying an item from the e-shop or letting her or him browse through the latest

[2] www.tobii.com
[3] https://www.empatica.com/en-eu/research/e4/
[4] www.noldus.com/human-behavior-research/products/facereader
[5] https://rapidminer.com

special offers, to improved customer experience levels, or to meeting user desires defined by the hidden mental states of the user. The adaptation component finally generates the necessary modifications of the interactive target application.

These architectural components are necessary for enabling the PaMGIS framework to support automated adaptive user interfaces. In the user interface construction process, the SitAdapt 2.0 evaluation and adaptation component cooperates with the models of the interactive application (abstract, concrete and final user interface model, context of use models, task and concept model) and can also access the HCI-patterns (not to be confused with the situation patterns) residing in the PaMGIS repositories to build the necessary modifications of the user interface at runtime.

III. Automating Customer Experience Optimization in E-Business

As a promising candidate domain for exploring situation analytics and situation-aware adaptation we have selected the e-business and e-commerce fields. In our current project we focus on a commercial cosmetics e-business portal.

A. *Dynamic Adaptation Features*

We have implemented dynamic adaptation features for pre-session, first session and recurring session adaptation. Typical adaptation features are related to the following areas:

Visual appearance of the application

- Gender or age specific coloring
- Gender or age specific image selections
- Soothing image or color selection
- Age specific element size
- Element ordering or widget selection dependent on age or emotional state
- Screen contrast dependent on clock time, bio-physical or emotional user state
- Font type, font size dependent on age, clock time, bio-physical or emotional user state

New user interface or content elements

- Tutorial-offering at first session or dependent of user age
- Help functionality, e.g. chat window, help menu item, tool tips, UI element tips dependent on user behavior
- Personalized fields and panes (user- and behavior-specific advertisement

Content-based adaptation

- Personalized product offers or suggestions
- Voucher offering dependent on user behavior
- User feedback functionality dependent on user behavior

B. *Complex Situation Examples for a Cosmetics Portal*

In a comprehensive user study with 9 female test persons we tested the usability, user experience and emotional behavior for several scenarios when interacting with a real-world cosmetics industry web-portal [1]. These tests served as the basis for finding domain-dependent situations and formulating situation rules. Due to the limited space we can only discuss some of the most interesting findings in this section.

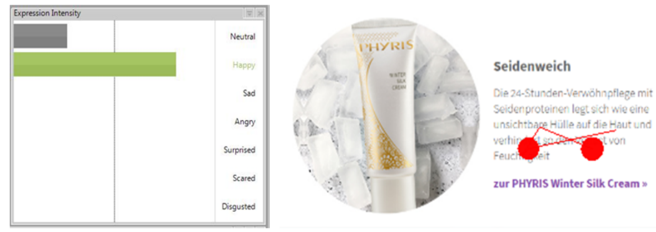

Fig. 3. Emotional reaction after finding the ideal product

In order to illustrate the potential of situation-aware adaptation we present some real-world situation examples and possible adaptive reactions. In the first example (Fig. 3) a test person is searching for a specific winter skin cream. Upon reading the detailed description of the product *Winter Silk Crème,* the user's emotional state significantly changes to *happy*. A situation rule could now exploit this knowledge to give additional information about other winter products. The improved customer experience near the purchase touch point can directly lead to a purchase of this and similar products.

In the next example (Fig. 4 and 5), the system has gathered a priori knowledge about the varying gaze behavior of test persons, who are known customers of the business or who are here for the first time, by distinguishing between the lab-created heat maps. The gaze behavior with respect to this image can be used to categorize anonymous users. The customer experience during the pre-purchase phase can be improved. When the system assumes a returning customer, the focus of her further customer journey will be put on showing aesthetic images, while in the other case more descriptive information will be given during the rest of the customer journey.

Fig. 4. Heatmap for customers of the business

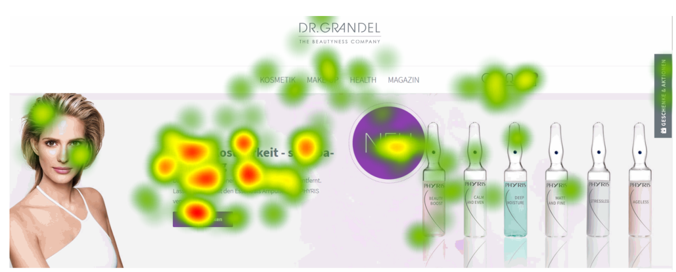

Fig. 5. Heatmap for first time users of the website

Another application area for using situation analytics in the e-business field is the evaluation and fine-tuning of pre-defined customer personas, which are used for pre-runtime adaptations and configurations of an application. Focusing on personas for a priori adaptation of the cosmetics portal can e.g. affect the visual appearance, the product content structure, the level of the product description language, the appearance of special advertisements, or the gaming and social media orientation of the website. Are test persons behaving like their respective personas or are there significant deviations from the expected behavior? This can be evaluated by comparing the situation profiles that come up during persona-adapted user tests with the typical situation profiles specified during the persona definition process. Vice-versa SitAdapt 2.0 can classify unknown customers or first time visitors into one of the given persona categories by analyzing the situations appearing during the session and by analyzing the users' behavior after situation-rule triggered adaptations.

All of these user observations and behavior evaluations as well as the adaptations of the interactive software are currently done in our situation analytics lab environment. The rapid evolution of visual and biophysical user tracking and monitoring technology will enable situation-aware individual adaptations for the end user in the near future.

C. *Adaptation Modeling and Adaptation Process*

By applying our MBUID approach, the modeling, generation and adaptation of the target website is done with the help of the PaMGIS framework and the integrated SitAdapt 2.0 system (Fig. 1). The PaMGIS framework is based on the Cameleon Reference Framework (CRF) [2], [18]. In the construction process first of all, the abstract user interface model (AUI) is generated from the information contained in the domain model of the application that includes a task model and the concept model (i.e. business model) and defines abstract user interface objects that are still independent of the context of use. This AUI model can then be transformed into a concrete user interface model (CUI) that already exploits the context of use model that includes the user, device, UI-Toolkit and environment model, and the dialog model, which is responsible for the dynamic user interface behavior. In the next step, the final user interface model (FUI) is generated by parsing the CUI model and by exploiting the context of use model and the layout model [15].

The first displayed version of the product e-commerce website is already adapted to the user. For example by using the age and target device information from the context of use model. The SitAdapt 2.0 system permanently monitors the user and recognizes the situations she or he is experiencing while viewing the webpage and interacting with the user interface. The evaluation component recognizes in the first example (Fig. 3), that the user reads the text attentively and that the level of the *happy* emotion surpasses a given minimum duration (e.g. more than 5 seconds). These data come from the raw situation sequences stored in the database by the recording component. The various inputs from the Facereader (emotion) and eye tracking (text screen field) and the metadata of the website (URL) were evaluated just in time by the situation analytics component that has created the following situation profile of the current situation:

```
<SituationProfile>
      <TargetApplication>Desktop_PC
      ...
      <Situation_product_view>
            <FUI_link> product_view
            <AUI_link>
            model_AUI_product_view_1
            <CUI_link>
      model_CUI_product_view_1
            <Dialog_link> product_view
            <Task_link> product_view
            <Concept_link>
      model_concept_Product_view_1
            <Eye_Tracking>
      Product_Textbox_Product_1(10 s)
            <USRUA_Age_Range>30-50
            <USRUA_Gender>female
            <EmotionalState> happy
            <UserPsychologicalState>
            <BiometricState>
                  <Pulse> normal
                  <StressLevel> green
                  ...
      </Situation_product_view>
</SituationProfile>
```

The evaluation and adaptation component examines the situation profile to decide, if an adaptation can take place. This is usually achieved by activating the responsible sub-set of situation rules in the rule editor (Fig 2.). Alternatively, the programmer or web designer can directly provide code for interpreting the situation profile in the web application client or server, which is triggered when the user interacts with specific elements of the user interface

In the concrete example, the situation rules specify that additional information about other winter cosmetic products should be displayed in this particular situation. The decision can be refined by also taking into account the user persona, if it is already known. For a strictly goal-oriented persona, a new window with additional product information may be shown. For a more cautious persona, a question text may appear, whether additional product information about winter products is welcome.

The evaluation and adaptation component now starts the adaptation process, which leads to the generation of a modified user interface. A new CUI and subsequently a FUI is generated and displayed to the user. The PaMGIS modeling environment must provide all the necessary models, model variants and model fragments necessary for user interface modifications. User interface models may contain links to HCI-patterns that can facilitate user interface code generation. More complex adaptations may also activate different tasks specified in the task model and require the activation of non-UI service code.

By observing the users' emotional behavior after such adaptations, the quality of the situation rules and the respective adaptations can be evaluated and rated. Such information can be used offline for refining the situation rule set for later use.

IV. Conclusion

SitAdapt 2.0 is an advanced architecture for automating user interface adaptation for responsive web-applications that were constructed with the PaMGIS MBUID framework. This paper has demonstrated the flexibility and versatility of this new approach by testing it with different scenarios and touch points of the customer journey in a commercial e-business platform for cosmetics products. It could be demonstrated that emotion recognition combined with eye- and gaze-tracking can be a powerful method for assessing situations and finding possible adaptations at application runtime. By the lab-based observation of users through multiple visual and physical channels we could establish a basis for improving the customer experience in the pre-purchase and after purchase phases, because the gathered knowledge can be used for optimizing a priori and persona-based adaptations and can lead to improved situation rules. A follow-up study that is currently under way will evaluate the effectiveness of the persona-based a priori and situation-aware runtime adaptations for the perceived individual customer experience.

In the future we will combine SitAdapt 2.0 functionality with web and big-data analytics to further improve the customer experience of e-business applications and to evaluate, which of the applied user monitoring technologies can be helpful in situation-aware end-user environments.

References

[1] Bissinger, B.C.: Messung und Analyse von bio-physischen und visuellen Daten zur Optimierung der User Experience und des Digitalmarketings, Master Thesis, Business Information Systems, Augsburg University of Applied Sciences, 2018

[2] Calvary, G., Coutaz, J., Bouillon, L. et al., 2002. “The CAMELEON Reference Framework”. Retrieved August 25, 2016 from http://giove.isti.cnr.it/projects/cameleon/pdf/CAMELEON%20D1.1RefFramework.pdf

[3] Chang, C.K.: Situation Analytics: A Foundation for a New Software Engineering Paradigm, IEEE Computer, Jan. 2016, pp. 24-33

[4] P. Ekman, “An argument for basic emotions,” Cogn. Emot., vol. 6, no. 3–4, pp. 169–200, 1992.

[5] Engel, J., Märtin, C., Forbrig, P.: Practical Aspects of Pattern-supported Model-driven User Interface Generation. Proc. HCI International 2017, Vancouver, Canada, 9-14 July, Vol. I, Springer LNCS, 2017, pp. 397-414

[6] Engel, J., Märtin, C., Forbrig, P.: A Concerted Model-driven and Pattern-based Framework for Developing User Interfaces of Interactive Ubiquitous Applications, Proc. First Int. Workshop on Large-scale and Model-based Interactive Systems, Duisburg, (2015), pp. 35-41

[7] Flach, J.M., Mulder, M, Van Paassen, M.M.: The Concept of the Situation in Psychology, in: Banbury, S. and Tremblay, S. (eds): A Cognitive Approach to Situation Awareness: Theory and Applications, Ashgate Publisching, Oxon (UK), (2004), pp. 42-60

[8] Galindo, J. et al.: Using user emotions to trigger UI adaptation, Proc. 12^{th} Int. Conf. on Research Challenges in Information Science (RCIS), (2018)

[9] Halvorsrud, R., Kvale, K., Følstad, A.: Improving Service Quality through Customer Journey Analysis, J. of service theory and practice, vol. 26, 6, (2016), pp. 840-867

[10] Herdin, C., Märtin, C., Forbrig, P.: SitAdapt: An architecture for situation-aware runtime adaptation of interactive systems. Proc. HCI International 2017, Vancouver, Canada, 9-14 July, Vol. I, Springer LNCS, 2017, pp. 447-455

[11] Hibbeln, Martin; Jenkins, Jeffrey L.; Schneider, Christoph; Valacich, Joseph S.; and Weinmann, Markus. 2017. "How Is Your User Feeling? Inferring Emotion Through Human Computer Interaction Devices," MIS Quarterly, (41: 1) pp.1-21.

[12] Hudlicka, E. and M. D. Mcneese, “Assessment of user affective and belief states for interface adaptation: Application to an Air Force pilot task,” User Model. User-Adapt. Interact., vol. 12, no. 1, pp. 1–47, 2002.

[13] Lemon, K.N., Verhoef, P.C.: Understanding Customer Experience Throughout the Customer Journey, J. of Marketing: AMA/MSI Special Issue, Vol. 80 (Nov. 2016), pp. 69-97

[14] Märtin, C., Herdin, C.: Enabling Decision-Making for Situation-Aware Adaptations of Interactive Systems, Proc. 10th Forum Media Technology, FMT 2017, 29-30 Nov., St. Pölten, Austria, (2017)

[15] Märtin, C., Herdin, C., Engel, J.: Model-based User-Interface Adaptation by Exploiting Situations, Emotions and Software Patterns, Proc. CHIRA 2017, Funchal, Madeira, Portugal, 31 October-2 November, SCITEPRESS (2017), pp. 50-59

[16] Märtin, C., Rashid, S., Herdin, C.: Designing Responsive Interactive Applications by Emotion-Tracking and Pattern-based Dynamic User Interface Adaptation. Proc. of HCII 2016, Toronto, 17-22 July, Vol. III, Springer LNCS, 2016, pp. 28-36

[17] Meixner, G., Calvary, G., Coutaz, J.: Introduction to model-based user interfaces. W3C Working Group Note 07 January 2014. http://www.w3.org/TR/mbui-intero/. Accessed 27 May 2015

[18] Melchior, J., Vanderdonckt, J., Van Roy, P.: A Model-Based Approach for Distributed User Interfaces, Proc. EICS ‘2011, ACM (2011), pp. 11-20

[19] Meudt, S. et al.: Going Further in Affective Computing: How Emotion Recognition Can Improve Adaptive User Interaction, in: A. Esposito and L.C. Jain (eds.), Toward Robotic Socially Believable Behaving Systems – Vol. 1, Intelligent Systems Reference Library 105, Springer Int. Publishing Switzerland (2016), pp. 73-103

[20] Nasoz, F.: “Adaptive intelligent user interfaces with emotion recognition, University of Central Florida Orlando, Florida, 2004.

[21] Picard, R.:”Recognizing Stress, Engagement, and Positive Emotion”, Proc. IUI 2015, March 29-April 1, 2015, Atlanta, GA, USA, pp. 3-4

[22] Schilit, B.N., Theimer, M.M.: Disseminating Active Map Information to Mobile Hosts, IEEE Network, vol. 8, no. 5, pp. 22–32, (1994)

[23] Schmidt, A. Biosignals in Human-Computer Interaction, Interactions Jan-Feb 2016, (2016), pp. 76-79

[24] Yigitbas, E., Sauer, S., Engels, G.: A Model-Based Framework for Multi-Adaptive Migratory User Interfaces. In: Proceedings of the HCI 2015, Part II, LNCS 9170, Springer (2015), pp. 563-572