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Customer feedback gathering and management tools for product-service system design

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Abstract

Modern manufacturing industries are being shifted towards a new business model where low cost and high customer value solutions should be designed and provided. The use of advanced technology and mobile applications will support companies to approach customers, and extract and analyze their opinion. Towards that, this research work presents tools for customers' feedback gathering and management to support efficient and accurate product and service designs. Mobile applications for customer feedback gathering on products and services and an importance-satisfaction analysis based on modular design approach are proposed. The tools are validated in a real case study from the robotics industry.

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Keywords: Feedback gathering; Feedback management; Mobile applications; Product-service systems; Design

1. Introduction

Companies nowadays provide their products to an expanded network that includes numerous markets [1]. In order to cope with the intense competition and also the diversity in customers' opinions, manufacturers need to take meaningful feedback from their customers on the provided products and the complementary services. After releasing a new product to the market, the company takes a series of actions so as to motivate the customers to provide feedback on the products they have acquired and after a long and time-consuming procedure, extract the customers' opinion and exploit this information for future product design. Implementing regional customers' requirements and constraints in a globally distributed product, through altering some modules and module features of the product, is the basis for frugal innovation [2,3,4].

Nowadays, smartphones and tablets are used by the majority of the population, while the number of users still grows. High penetration of mobile devices in the society has become a great opportunity for manufacturers to promote their products, provide 3D product customization applications [5] or even provide product related services. Meaningful feedback from customers can be collected using mobile devices. These opinions can be used as guide for improving available products and product-services.

This paper addresses the need for customer feedback gathering for the provided products and product-services through a highly usable mobile device application so as to efficiently extract customer requirements and to support companies to move towards frugal innovation. Moreover, the approach includes a feedback management application that facilitates the company to shape the customers' opinion into meaningful and targeting to a market for future products and service design. To achieve that, the proposed work presents a

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mobile application for product, as well as for service feedback gathering. The collected data are integrated and analyzed by a feedback management tool, aiming to extract meaningful insights for future product-service system design.

2. State of the Art

Customer's requirements and satisfaction are governed by geographical and economic factors, context of use, local and international administration, resource usage and standards [6]. To make a more accurate and effective plan for product and service design, a company should be aware of the economic trends and the prevailing direction of the living standards of targeted markets and countries. It is important to develop technology to support interactions with real customers and to quickly capture their opinion on the available product-service in order to extract requirements of a market and also to improve products and services provided into a market [7]. This will help in increasing the requirements accuracy for future product and service design. The integration of customer's during the product lifecycle and the retrieval of regional customer requirements is also part of a new business model introduced by frugal innovation concept [8].

Extracting customers' feedback is a challenging process since customers' opinion is usually gathered for the product as a whole and is not easily modulated and quantified [1]. Modern companies design their strategies on how to approach their customers, based on the actions and the techniques that will be used to allow them to measure customers' product satisfaction and exploit their suggestions [9]. Setting up customer product support call line(s) that encourage customers to express their opinion on the acquired products and questionnaires that, either through phone calls or through product selling points, where the questionnaires are provided in the paper, reach out to the customers for the valuable product feedback [10].

Recently, a transition from the currently installed rigid enterprise systems towards decentralized and distributed cloud-based IT systems is observed. Enabling technologies to support the implementation of this trend are cloud computing, in-memory applications and enterprise mobility [11]. Although the term mobility may be interpreted as the movement of physical manufacturing resources [11], in this work it is defined as 'the ability of a stakeholder to remain constantly and interactively connected to the company's fundamental activities and allow taking decisions remotely' [12]. Modern approaches, exploit web-based questionnaire solutions, most commonly Google Forms®, which provide a user-friendly interface that can be easily sent to or accessed online from customers all around the world [13]. Mobile applications are more and more adopted by companies aiming to provide user-friendly and easy to use tools to their customers and retrieve valuable feedback for the provided products and services [11]. However, mobile apps easily interconnected with companies' main ICT systems that can provide analyzed information easily and effectively is a field of further investigation.

Several approaches are reported in the literature for the management and analysis of the customer feedback data. The most reported approaches for customer feedback gathering and analysis focus on after sales (usage) feedback for marketing purposes and are based on one of Importance–Performance Analysis (IPA), KANO model or conjoint analysis. IPA is widely used for analysis and interpretation of customer satisfaction for a product or a product service [14]. KANO model [15] is another widely used model for analysis and interpretation of customer satisfaction and classifies customer preferences. The KANO model distinguishes among three types of product requirements as must-be, one-dimensional and attractive requirements which influence customer satisfaction in different ways [15]. Conjoint analysis [16] is particularly adapted to measure preference for multi attribute products. Violante and Vezzetti [17] present a detailed comparison between more than 15 enriched quantitative Kano models. For addressing the customer's opinion in design, it is required to classify the modules and attributes both qualitatively and quantitatively.

The ever-increasing need for product customization and for feedback gathering so as to improve and re-design provided products and product-services, ask for business approaches, which are able to provide locally adaptable offerings, without loss in terms of efficiency, in a systematized manner [18]. To achieve that, new product-services, related advanced Information and Communication Technology (ICT) and cloud-based tools should be developed, allowing the co-evolution of products (and services), processes, and production systems, according to localized customers' needs and production sites capabilities [19]. Existing approaches are mainly focused on retrieving feedback about the provided products without considering combined product-services systems. Product-Service Systems (PSS) refer to the hybrid solution of providing services together or instead of the product's ownership, securing high competitiveness and sustainability via the creation of added customer value [20]. The proposal work, contributes to the field of frugal innovation by gathering and analyzing customer's feedback on the products and product services. In addition to that, it presents a mobile application for feedback gathering supporting 3D visualizations for a user-friendly environment. The mobile feedback gathering tool is used to get the pulse of a targeted market, aiming to support the companies to improve their products. The data that are collected through the developed application are then transmitted into a PLM repository where a feedback management tool classifies the modules of the products and product services both qualitatively and quantitatively, analyzing them and providing meaningful results and feedback for product-service systems re-design and future improvement.

3. Customer Feedback gathering and management for product-service systems design

In the present work, a combined approach for feedback gathering and management is presented, aiming to address existing challenges and support companies to easily improve and re-design their product-services systems. The proposed approach consists of two main parts:

- Mobile application supported by 3D animation and visualization for feedback gathering;
- Feedback management that retrieves the collected data and analyzes them through a classification of product-service modules.

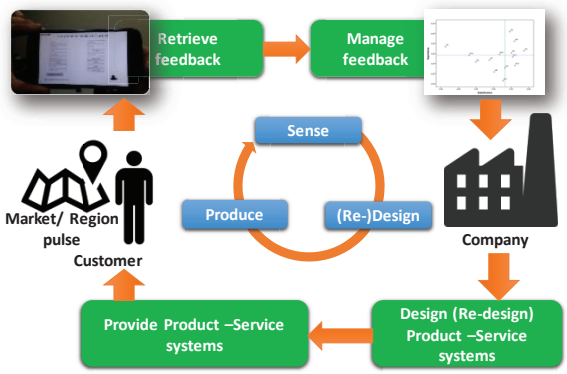

Fig. 1 Proposed framework.

Each one of the main parts of the proposed approach is presented in detail in the following sub-sections. The proposed tools can also support companies that are moving towards frugal innovation to easily get the pulse of the market and design high value targeted solutions (product-services) (Fig .1).

3.1. Feedback Gathering for product and product-service Design

In order for the OEMs to stay connected to their customers, to make sure that product development is towards the right direction and that the quality of the provided services is adequate, their sales department takes a set of actions to perform product performance evaluation. To do so, a carefully designed questionnaire is created, aiming to extract as much information as possible for the existing products and the product-services (Fig. 2). The developed tool integrates this questionnaire, in a way that attracts customers' interest but is also easy to analyze, asking for each question the customer's importance and satisfaction, based on Likert's 10-point scale (1: Highly unsatisfied/ unimportant, 10: Highly satisfied/ important) [21]. The proposed tool is developed as a mobile device application which exploits the high-quality GUIs and 3D geometries to make the process more interesting for the customer. Moreover, it uses the internet connection to retrieve the customers' answers from everywhere to the company in a digitalized and automated way, omitting the resource-consuming traditional method of paper-based survey forms.

The end user receives this application through a web channel (either through the corresponding app store like any other application or through the OEM's website). Initially, the customer signs in, providing an email and some details about themselves such as region, type of use (professional or individual) and age (Fig. 2). This is important for two reasons: (i) it secures (to a certain level) the credibility and the uniqueness of each provided feedback and (ii) it allows the OEM to filter the results, targeting different groups of end users each time, for each product and adding different weights for each target group. Thus, it allows regional sales managers to participate in the survey with an increased weighting.

Then, the end user is called to provide product feedback. To make easier for each customer to identify the acquired product and to avoid any mistakes, a QR code scan feature has been introduced in the mobile application. The QR code may be provided with the product to the customer (e.g. inside the product's manual). Moving on to the survey, the customer is primarily asked to evaluate the product as a whole. The questions refer to the core product, forming the basis of the product feedback. Then, the customer moves on to the targeted questions, which ask him/ her to provide feedback targeted to specific product modules. These modules may vary, as they reflect the customizable options the OEM offers for this product. In an effort to improve the interface and make it more fascinating and functional for the end user, 3D models have been implemented in the application. The customer may tap on a module in the product (modular product architecture [6]) and provide his feedback on the targeted questions that are visualized. Moreover, the customer is asked to evaluate the product-service that is provided (Fig. 2). Using the same application and following the format of the product-related questions, the customer is asked a set of carefully selected questions that cover all the aspects of the complementary service, such as cost, quality, and required time (Fig. 2). This is an important part of the evaluation as the customer evaluated the product and the product-service separately, through carefully selected questions that target different product modules, thus facilitating the connection of the customers' answers with the product modules.

Finalizing the evaluation, the customer is asked to provide any comments/suggestions he/she may have in free text. Though this cannot be mathematically analyzed, they may provide useful comments or even proposals for additional modules or features for the product and product-service designers. All the data provided by the customer are then bundled in an xml file and sent to the OEM for analysis (Fig. 2).

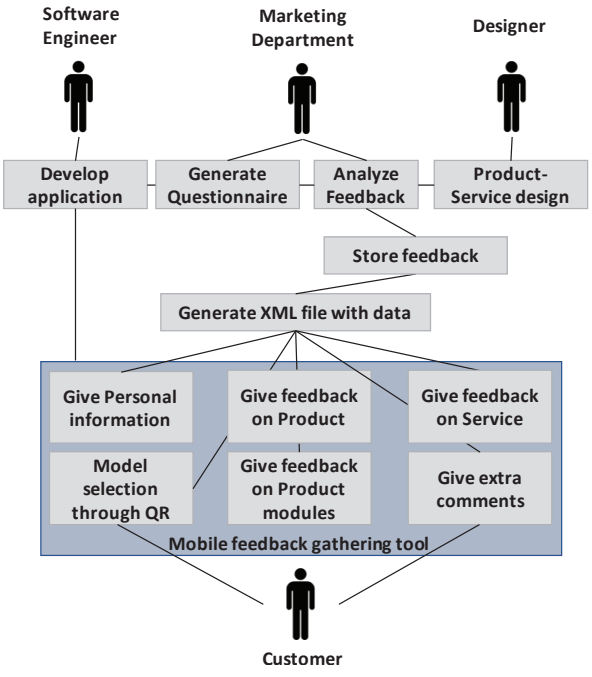

Fig. 2. The feedback gathering tool.

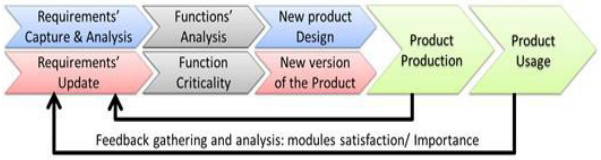

Fig. 3. Global process of customer-driven product and product-service design [22].

3.2. Feedback Management for Product and Product-service Design

Formalized and structured process to gather feedback including customers' opinions and analysis of the feedback for product and product-service design is needed for the design of today's product and product-service. Requirements can vary across geographical regions e.g. socio-economic factors, localization (local governing rules, cultural factors, resource usages and market trend) and globalization (international policies and standards) [9].

Global process of customer-driven product and product-service design based on customers' opinion is presented in Fig. 3. The proposed approach utilizes customers' opinion for improving product and product-services as iterative product development for addressing a market needs. Customers' opinion means validation of modules in the product and product-service, and additional requirements if a customer(s) is not satisfied with the proposed solutions (modules in the product and product-service). The opinion on a product is gathered once a module is available during production for validation and also on the product when it is used by the customer.

Available products and product-services are first used for customers' opinion. The collected customers' opinions are analyzed to compute market representatives and corrections needed in the product and product-service which are then used for updating requirements and design criteria for product and product-service design as depicted in Fig. 3. Function refers to a purpose of a module in a product or product-service system.

A conceptual model (SIE model: Satisfaction Importance Evaluation model) for feedback analysis for product development perspective is presented in paper [21]. In this model, customers' opinion from a market segment are used for prioritization of feedback on modules and for computing corrections needed to make a module fit to that market.

3.2.1. Modularity for design and feedback connection

Modularity-based design is the process to create modular product architectures as sets of common modules that are shared among a product family [8]. Respecting the modularity approach principles, the identification of all possible alternatives of modules responding to the selected list of functions are identified either collectively, through the reuse of existing generic product architecture matching with all requested functions, or by mapping functions individually to various modules. Examples of these two ways of modular product design are available in literature [6, 23]. In the case of mapping functions individually to various modules, more flexibility is allowed in the selection of product modules and consequently more innovative possibilities for the final product alternatives. However, more attention is required for the global consistency of the whole structure. Indeed, the process of modular design is a decision-making process where finding consensus between conflicting criteria is a critical issue. These conflicts are mainly coming from interfacing problems between modules and common parameters with various values depending on disciplinary perspective (e.g. mechanical, electrical, etc.) [23]. To resolve such conflicts, the designer has to set up a prioritization strategy based on the analysis of customer requirements and constraints. Function criticality is currently the best way to represent the propagation of these requirements/constraints into technical recommendation to be considered in the designed solution. It is the importance of one function for the client regarding the whole added value of the final product. Thus, better consideration of the customer opinion to identify what is most important for him/her will help designer to set the prioritization strategy in the design process of the future version of the product. To do so, the customer should get the possibility to provide his feedback not only in terms of satisfaction on the whole product architecture, but to decentralize his feedback on a list of modules and features, while precising the importance of each module/feature for his final use e.g. operation, maintenance, reuse and disposal.

3.2.2. Feedback prioritization and utilization in product and product-service design

Modular organization of the product, product-service and production system for the analysis of the customers' opinions to identify whether a module in a product is poor design, over design or frugal design is presented in previous work of the authors [24]. The collected feedback is analyzed for prioritization of modules considered in the product as poor design, over design and frugal design and to compute corrections needed for the product and product-service design.

A poor design module has low satisfaction and high importance in customers' view. A poor design module should be replaced (or redesigned) to improve quality, performance, material, and/or capacity as per the requirements identified to improve the customer satisfaction and corrections needed.

An over design module has high satisfaction and low importance in customers' view. Customers are delighted with such kind of modules. An over design module can be replaced with a module of lower cost to gain advantages of reduction in cost, time and resources. The company may replace this module by low-cost (or economical) module according to the corrections needed. A frugal design module has satisfaction and importance levels according to the levels of frugal criteria (e.g. function, robust, user-friendly, growing, affordable, and local) identified for a targeted market [8]. A frugal design module can be used in a product and product-service design without change in utilization of resources used. The frugal design module in the product can be utilized in the next version of the product with the same design, production, packaging and transportation facilities used.

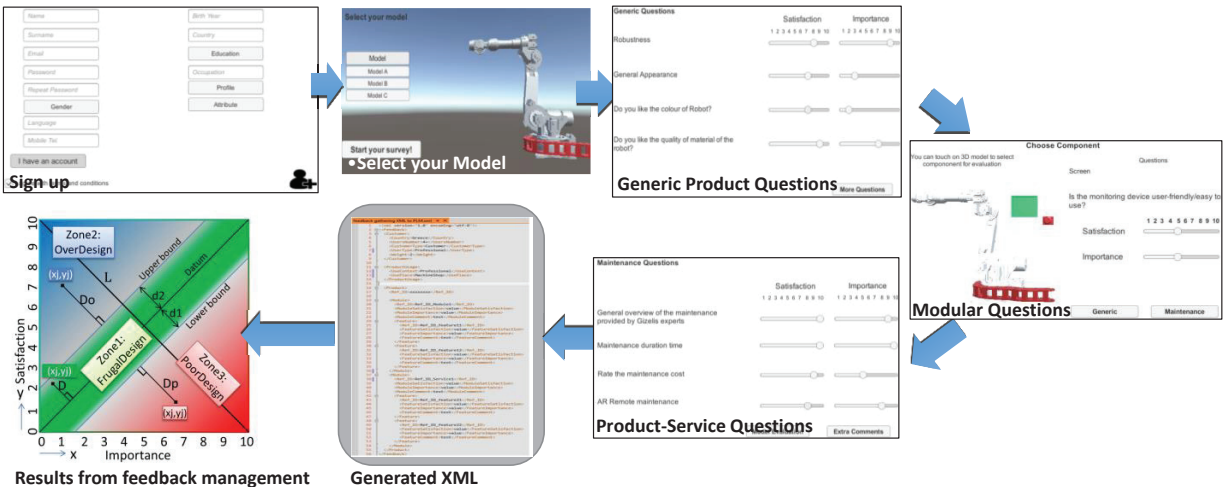

Fig. 4. The results of the feedback gathering and the feedback management tools.

4. Case study and Results

The developed tools were implemented on a case study provided by a robotics SME. The robotics SME provides to its customers a product-service system which consider the different robotic systems as products and their remote maintenance as product-service. This combined product-service system supports the company to provide an added value solution to its customers.

One of the main steps during this product-service system provision is the feedback retrieved from the customers on both the product and product-service. The mobile application has been designed for the robotics case including feedback on the product modules as well as on the product-service modules as presented in the table below:

Mobile application for feedback, feedback management for product and product-service design, and integration with PLM repository have been developed. The results are presented in Fig. 4. The defined product and product-service features and modules on which feedback has been received are presented in the table below.

Table 1. The defined features and modules for feedback.

Product-Service System	Feedback
Product as a whole	General appearance
	Robustness
	Color
	Material
Product modules	Instructions manual
	Cable management
	Safety buttons
	Monitoring device
Service as a whole	Cost
	Duration
	General Satisfaction

The robotics company, through the developed approach, is capable of retrieving easily and effectively the feedback from their customers compared to the existing approach (phone calls and web meetings), and also is able to analyze efficiently the collected data focusing on the product and product-service modules that are of high importance and their re-design or improvement is highly required following the feedback analysis.

5. Conclusions

The proposed work presents an approach for feedback gathering and management supported by a mobile application and an effective feedback management method. The developed system aims to support product-service system design by integrating the customers' opinion. The proposed approach through the easy-to-use, user-friendly, enhanced with 3D visualization functionalities, mobile application as well as with the feedback management tool supports companies to easily retrieve feedback from the market, analyze it and react by improving the provided product-services systems. The developed systems also enable companies to design high added value and targeted solutions to the market or by effectively re-designing the existing ones and transforming them into what the market really requires. The provision of ICT tools and the digitalization of the procedure aim to increase the response rate and the customer's satisfaction. Finally, the developed approach can support companies that are moving towards frugal innovation to easily sense the market needs and provide targeted products and product-services to different regions and markets.

In future work, the proposed methodology will be enhanced and will be also applied in more industrial case studies.

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References

[1] Chryssolouris G, Manufacturing systems: theory and practice, 2nd Ed. Springer Science & Business Media; 2013.
[2] Mourtzis D, Vlachou E, Boli N, Gravias L, Giannoulis C. Manufacturing Networks Design through Smart Decision Making towards Frugal Innovation, Procedia CIRP 2016;50: 354-359.
[3] Berger R. Frugal products: Study results; 2013 Available from: https://www.rolandberger.com/media/pdf/Roland_Berger_Frugal_products_20130212.pdf.
[4] Arndt T, Hochdörffer J, Moser E, Peters S, Lanza G. Customer-driven Planning and Control of Global Production Networks - Balancing Standardisation and Regionalisation. In: Proceedings of the 18th Cambridge International Manufacturing Symposium, Cambridge, UK; 2014. pp. 60-74.
[5] IKEA Store, https://play.google.com/store/apps/details?id=com.ikea.kompis&hl=en.
[6] Gupta RK, Belkadi F, Bernard A. Adaptation of european product to emerging markets: modular product development. In: 15ème Colloque national AIP-PRIMECA, La Plagne, France; 2017.
[7] SaS. How can we use social media data to detect customer issues sooner?; 2011.
[8] Mourtzis D, Vlachou E, Giannoulis C, Siganakis E, Zogopoulos V. Applications for frugal product customization and design of manufacturing networks. Procedia CIRP 2016; 52:228-233.
[9] Sampson SE. Gathering customer feedback via the internet: Instrument and prospects, Industrial Management and Data Systems, 1998; 98(2): 71-82.
[10] Opoku RA. Gathering customer feedback online and Swedish SMEs, Management Research News, 2006; 29(3):106 – 127.
[11] Stillström C, Jackson M. The Concept of Mobile Manufacturing, Journal of Manufacturing Systems. 2007:26: 188– 193. doi:10.1016/j.jmsy.2008.03.002.
[12] Mourtzis D, Doukas M, Vandera C. Mobile Apps for Product Customisation and Design of Manufacturing Networks. Manufacturing Letters 2014;2 (2): 30–34. doi:10.1016/j.mfglet.2014.01.002.
[13] Dillman DA. Mail and internet surveys: The tailored design method, New York: Wiley, Vol. 2; 2002.
[14] Chen YC, Lin S. Applying importance-performance analysis for improving internal marketing of hospital management in Taiwan. International Business Research 2013; 6(4). http://dx.doi.org/10.5539/ibr.v6n4p45
[15] Kano N, Seraku N, Takahashi F, Tsuji S. Attractive quality and must-be quality. Hinshitsu: The Journal of the Japanese Society for Quality Control 1984; 14(2):39–48.
[16] Luce RD. Simultaneous conjoint measurement: A new type of fundamental measurement. Journal of Mathematical Psychology 1964; 1:1–27.
[17] Violante MG, Vezzetti E. Kano qualitative vs quantitative approaches: An assessment framework for products attributes analysis. Computers in Industry 2014; 86:15-25.
[18] Colledani M, Silipo L, Yemane A, Lanza G, Börgin J, Hochdörffer J, Georgoulias K, Mourtzis D, Bitte F, Bernard A, Belkadi F. Technology-based product-services for supporting frugal innovation, Procedia CIRP, 2016; 47: pp.126–131
[19] Normann G. Likert scales, levels of measurement and the "laws" of statistics, Advances in Health Sciences Education 2010; 15(5): 625–632.
[20] Kimita K, Shimomura Y, Arai T. Evaluation of customer satisfaction for PSS design. Journal of Manufacturing Technology Management. 2009 June 5;20(5):654-73.
[21] Gupta RK, Belkadi F, Bernard A. Evaluation and management of customer feedback to include market dynamics into product development: Satisfaction Importance Evaluation (SIE) model. In: 21st International Conference on Engineering Design,Vancouver, British Columbia, Canada; 2017
[22] ProRegio: Customer-driven design of product-services and production networks to adapt to regional market requirements, European Union's Horizon 2020 research and innovation project, 2015-2017. http://www.h2020-proregio.eu/.
[23] Salhieh SM, Kamrani AK. Macro level product development using design for modularity. Robotics and Computer integrated manufacturing 1999; 15:319-329.
[24] Ouamer-Ali MI, Belkadi F, Laroche F, Remy S, Bernard A. Points of view classification: A concept to manage knowledge multi-representation in CAD models and PDM/PLM systems. In: 13th annual International CAD Conference, Vancouver (Canada);2016.