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# Qualitative comparison of requirements elicitation techniques that are used to collect feedback information about product use

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**Abstract**

User-centric design requires the application of different techniques to elicit user requirements. Many of these techniques deduct requirements from feedback information concerning a product's actual use. Typical approaches are inquiry and observation of users. While most techniques collect subjective use information, novel techniques, such as product-embedded sensors, can retrieve objective data that can be further processed. The paper compares a selection of eight techniques used in requirements elicitation. The techniques are evaluated according to six qualitative criteria with a focus on the terms of information collection and the qualities of that information. The qualitative results are illustrated through net-diagrams that can be used to further argue on the techniques, especially in areas where requirements for individual users need to be elicited.

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Keywords: requirements elicitation; comparison; elicitation techniques, embedded sensors, feedback information

## 1. Introduction

User-centric design processes are characterized by an early focus on users and tasks. The applied focus varies along a continuum ranging from an informative to a thorough participative role of users [1]. Typically, companies involve users during the early stages of a new or an adapted product design when user needs become formalized through user requirements. User requirements decide about future design decisions and a lack of understanding in this early stage can have serious negative impact on later stages in a product's lifecycle [2]. In order to avoid these problems, Gould and Lewis recommend the application of empirical measurement of user performance complemented with an iterative design process [3]. Empirical measurement of user performance however is difficult since part of the required knowledge is tacit [4], [5]. According to Nonaka, tacit knowledge is difficult to codify and requires socialization to be transferred from one person to another [6]. Management of this knowledge transfer during product development is realized through requirements engineering. In order to collect feedback information from the user about the use of a certain product, general techniques like inquiry and observation can be applied. Observation of users in their natural environments is one of the most recent and promising approaches for the collection of feedback information. A recent example for this approach is the field of living labs. Living labs are environments for the exploration and evaluation of new products in realistic situations.

Another important development in the last decade concerns the significant advances in information and communication technology. Cost and size reduction of micro-electronic components, such as sensors, actuators, batteries, and microcontrollers facilitate the design of an increasing variety of products labeled as smart or intelligent. Examples for smart products include mobile phones, automobiles and manufacturing machines. All these products feature selections of *product-embedded sensors*. Embedded sensors are used to collect data about the individual product and its surrounding. Typically these data are transformed into information that is

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enabling or supporting autonomous product behavior (e.g. automatic eco-mode, context-aware functions) and advanced services (e.g. predictive maintenance). Furthermore, sensors can be beneficial in requirements engineering, since they are a source of objective product use information [7]. Objective product use information doesn't contain the personal (biased) opinions of stakeholders.

This paper intends to provide a comparison of different techniques used in requirements elicitation with a focus on feedback information about the actual product use. The comparison will feature embedded sensors as an approaching technique to collect information. For this purpose, section 2 introduces key topics related to the paper's research question. Section 3 covers the research methodology and it will briefly explain a selection of common techniques used in requirements elicitation. In section 4, the qualitative evaluation of selected techniques is argued and illustrated. Finally, section 5 concludes the presented approach and findings of this paper.

## 2. Related work

### *2.1. Requirements engineering*

Requirements engineering (RE) is a process conducted during the early phases of product development. The ideas of RE come from the domain of software development, therefore, earlier work has a dedicated focus on software. Due to the increasing complexity of physical products, RE is relevant for the development this kind of products as well. According to Ebert, RE concerns the elicitation, documentation, analysis, evaluation, negotiation and management of requirements [8]. At the end of the whole process, stakeholder needs are codified and translated into technical specifications of the product [2]. Product specifications are used in subsequent development steps, as well as further processes like manufacturing and service.

The involvement of users in the elicitation of requirements is of major concern, with respect to the user-centered design approach. Requirements elicitation covers the systematic extraction of user requirements from different sources (e.g. the user or service documents). It consists of subsequent process steps like stakeholder and success factor identification, systematic framing, documentation, structuring, modeling and consolidation of requirements [8]. While the requirements elicitation typically marks the beginning of the product lifecycle, the inbound information for the elicitation process originates from several product lifecycle phases (e.g. manufacturing, use, service, recycling and disposal). Product use information (PUI) is the main source of user requirements with respect to user-centered design. PUI is typically conveyed by retrospective user feedback from the actual use phase of the product. According to Abramovici et.al, feedback related to PUI can be subjective or objective [9]. While retrospective user feedback is subjective, sporadically acquired data from sensors and service personnel is more of an objective kind. In order to collect feedback information to elicit requirements, different techniques in many variants can be applied [10].

### *2.2. Sensors*

An improved miniaturization level and further cost reduction of micro-electric components has lead to excessive integration of computing devices in numerous products. Premium products, such as cars and leisure boats, but also valuable consumer goods like cell phones and watches nowadays contain an increasing amount of sensors. Formally, a sensor can be defined as a system measuring physical quantities. Typical output of a sensor is an analogue signal that is interfaced into an analogue-to-digital converter (ADC). Some commercial sensors produce digital outputs through an embedded converter. One or more sensors as well as the ADC form a sensing unit. This unit is typically connected to a microcontroller for further data processing. Microcontroller and sensing unit are powered by an energy source. In order to collect data from geographically distributed sensors, a (wireless) communication module can be connected to the microcontroller and the energy source. A technical system consisting of a sensing unit, microcontroller, communication module and energy source is called sensor node. A model of a sensor node is illustrated in Fig. 1. Since raw sensor data has a very limited use, further processing through data analysis is required in order to derive useful information. For this purpose, approaches like data filters, descriptive and inferential statistics, or graphical data analysis can be applied. With these approaches, working hypotheses can be verified and data patterns identified for further investigation.

## 3. Methodology

Due to the large amount of available techniques for requirements elicitation, only a selection of techniques can be covered in this paper. Some of the selected techniques are taken from literature ([8], [11], [12], and [13]), while others are common-sense instruments to retrieve information (e.g. questionnaire or interview). Requirements elicitation techniques can be clustered, for instance into creativity, inquiry, observation and evolution techniques [12]. Creativity techniques like brainstorming are omitted in this paper, since they are more suited to collect requirements during the new product design process rather than the use phase. Techniques based on virtual products (e.g. simulation) and similar approaches are excluded as well. The evaluation conducted in this paper assumes that all covered techniques are applied in natural environments rather than controlled laboratories. In the following section, the selected techniques are briefly

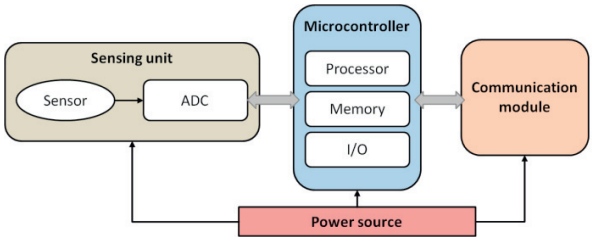


Figure 1: Components of a sensor node

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