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A Smart System to Standardize the Specifications of Haptic Quality Control

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Abstract

The specific attention paid to the quality perceived through the senses of costumers when touching a product has led to a rapid growth in the industrial interest for the field of haptics. Controlling the quality of products with such expectations has become a challenge for manufacturers, especially considering the current lack of a generic method to standardize control specifications and provide efficient control tools, whether a manual or automated control is considered. This study provides a new insight on the definition of control specifications regarding perceived quality control. Smart systems have proven useful and efficient in a number of other domains, but has never been applied in a generic manner to the control of the quality related to the sense of touch. Therefore, a system based on formalized knowledge on haptic perceptions and its relations with quality control is proposed. This paper presents the proposed approach for the standardization of haptic quality control specifications, along with an example of a manufacturing application. The structure of the proposed knowledge model is detailed, as well as the semantic approach that enabled the development of a formalized haptic sensation vocabulary. An experimental method was used to model the influence of exploration on perception, considering the application case.

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1. Introduction

Defining specifications for the control of a product that involves human perceptions remains a challenge for manufacturers. Recent studies have overcome some of these issues regarding the visual quality of products [1,2], but the sense of touch is still an issue in most industrial applications. In particular, domains of the industry where haptics sensations rendered by a product have an important factor on costumers satisfaction, such as wearable products (watch, bracelets,

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etc.) for instance, it is necessary to provide precise and shared control specifications, so the control protocols can be as efficient as possible.

Although the series of ISO norms related to the Geometrical Product Specifications (GPS) provides some information on surface texture specifications (e.g.[3]), it does not link to the human perception and to the vocabulary that can be used to describe the sensations perceived. Knowing that touch is a complex sense that involves sensory receptors spread all over the human body and that react to external or internal stimuli, the human way of expressing perceived sensations is also complex. It has evolved, along with languages to become the words we know, that can also be commonly used to describe the quality of manufactured product. Examples of such descriptions would be: "this paper page is soft", "this book is hard", etc.

However, in an industrial context of quality control, natural language tends to lead to problems because it induces the use of experience from the human controller that may not have the same perception of a similar word. For instance, one controller could perceive a page as "soft" whereas another would not, because the word "soft" might not have exactly the same meaning for these two persons, even though they both had the same sensation[4]. Thus, their perception of this sensation differed.

These issues were observed in a case study performed on a luxury watch product. In this particular case three main problems were encountered:

- The diversity of the language used to describe the expected or unexpected quality of the products, different from one person to another.
- Differences from one person to another in the perception related to a specific word.
- Disagreements on the definition of the expected quality of the product, even without using words (deciding by touching only).

Many of these problems are not specific to this case and can be observed on other applications cases and considering other industrial domains. The immediate consequences on the quality control are protocols that leave space for the human subjectivity, and hence a great variability in the acceptability decisions of the products. In order to overcome these issues and build standardized specifications for the control of the haptic quality of a product, three main contributions are proposed:

- Formalizing the vocabulary used to describe haptic sensations, in a generic way.
- Defining a precise association model between the formalized description of sensation and the descriptors (words) commonly used.
- Proposing guidelines for the definition of shared haptic quality control specifications.

In order to structure and implement the methods, a knowledge-based approach has been used. It involves the use of semantic methods for the formalization parts and an ontological representation for the structuring of the knowledge. One can note that this project focuses on the definition of specifications for the quality control process. Thus, the aim is not to study the preferences of costumers in order to design a product, although some elements of the proposed methods could possibly be used for this purpose (e.g. the formalized description of haptic sensations).

This paper is structured as follows. Section 2 presents the global structure of the proposed smart system. Section 3 details the proposed formalized description of haptic sensations and its representation in the ontological model. Finally section 4 explains the process of guiding manufacturers through the definition of the specifications using the proposed methods. These sections integrate elements of the application case performed on luxury watch bracelets.

2. Structuring haptic quality control knowledge

The use of formal models, such as ontologies, is essential for the development of smart systems. Very few studies have proposed ontologies directly related to the description of human perceptions and quality control. This is why a novel way to model knowledge related to the description and control of perceived quality was proposed and detailed in a previous publication[5]. Some elements of the global knowledge structure are reminded here, and the proposed *Sensory Perception* ontology is detailed considering the sense of touch.