Theoretical framework of universal design principle (UDP) approach considering haptic exploratory procedure (HEP) of visually impaired person in using TRIZ integration.

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Abstract. Visually impaired person has a difficulty in identifying the product function and usability. There is a need to integrate haptic exploratory procedure (HEP) of visually impaired person with universal design principle (UDP) in order to construct structural design approach. The purpose of this study is to construct theoretical framework for universal design approach considering haptic exploratory procedure (HEP). This study uses literature on visually impaired person haptic exploratory procedure (HEP) in order to identify the object properties translated by visually impaired person. Then, it uses literature of universal design to identify universal design approach in concept design process. Then, approach of TRIZ is explored in proposing systematic approach. Finally, the results are expected to lead towards model of theoretical framework of universal design approach using TRIZ and HEP. It can provide a helpful foundation for structuring the experiences to develop further the knowledge and understanding of objects for universal design. This theoretical framework contributes in designing structural UDP approach with consideration of visually impaired person HEP. It improves product usability in designing a universal design for visually impaired person.

1. Introduction
Recent statistic published by World Health Organization (WHO) in October 2018, estimate 1.3 billion people live with some form of vision impairment. With regards to distance vision, 188.5 million people have mild vision impairment, 217 million have moderate to severe vision impairment, and 36 million people are blind. Visual sense is important in guiding humans to move around and navigate through path in known and unknown environments regardless indoor or outdoor. Unfortunately, visually impaired person often faces a challenge in performing daily life routine task. In order to support spatial mapping of visually impaired person, two level of orientation skill which are perceptual and conceptual are widely studied [1], [2]. Visually impaired person relies on the auditory and haptic sensory in order to help them in daily life [3]

Haptic exploratory can be described as perception that relates to the sense of touch, particularly to the ways in which it is possible to discriminate and recognize objects from handling them as opposed to looking at them (Bushnell & Boudreau, 1993). Haptics is commonly viewed as perceptual system that most typically involves active manual exploration. While vision furthermore perceived for giving exceedingly exact spatial and temporal data, the haptic exploratory framework is particularly powerful at processing the material qualities of surfaces and objects [4].
Good design is represented by the human factors before design specifications are made (Nielsen, 1994). It is important for designers to consider basic human processing requirements in order to produce “user friendly” or universal designed products. Universal design has unique challenges because it aims to improve usability for a wide range of users. Universal design philosophy is a transfer towards inclusion promising improved solutions for people with diverse abilities. As stated by Singh & Tandon, (2016) universal design is important in order to aims to integrate various user groups within the design space to benefit the user of all ages with distinct abilities.

2. Review of Literature

2.1. Spatial Perception

In order to understand the needs of visually impaired person need in using product, a review on literature related to spatial perception of visually impaired person is reviewed. Majerova, (2015) highlights the important role of compensatory function of hearing, touch, smell and taste involved in perception of information process by the mental to evaluate. Smitsman & Schellingerhout, (2000) state that key to understand the exploration of blind infant is through kinesthesis and cutaneous sense. Brain will construct conscious image through stimulation of sensory system. This involves the recognition that stimulation has occurred and the ability to discriminate various aspects of the stimulus. Rhodes and Castel, (2008) state that the relation between cognition and perception to show that the size of a stimulus influences its perceived memorability.

Haptic sensory is specific to touch stimuli. Haptic memory is used regularly when assessing the necessary forces for gripping and interacting with familiar objects (Johansson et al., 1993). R. L. Klatzky & Lederman, (1992) state that human explored through touching in two stages, stage 1 is grasp/lifting then executing further exploratory procedures. In stage 1 of exploratory, sufficient information about multiple object properties is extracted, whereas in stage 2 was directed toward precise information about particularly diagnostic properties.

2.2. Haptic Exploratory Procedure

Human has use common behaviour in using their senses in order to explore or identify any objects they held. Klatzky, Lederman, & Matula, (1993) found that human performed highly stereotypical movements patterns using their hand, which possessed both necessary and typical features. Generally, this movement patterns are done unconsciously by human. The movement patterns are called exploratory procedure by Lederman & Klatzky, (1987) in their study. Eight exploratory procedure highlighted by Klatzky & Lederman, (1992, 1993).

Human also strategize the exploratory procedure sequence in order to identify or discriminate objects they currently explore [10]–[12]. Human normally combine different exploratory procedure during exploration to enhance the exploration speed. This statement is supported by study by Sommer & Billard, (2016), haptic exploration on tactile sensor offer more efficient when applied on multiple contact point. Therefore, haptic sensory is important in developing good design for visually impaired person.

2.3. Universal Design

Universal design (also known as inclusive design in United Kingdom and Design for All in Europe) is not a special requirement, for the benefit of only a minority of the population [14], [15]. It is a fundamental condition of good design. However, product design is often base on subjective understanding of designers and does not involve accurate conversion in design needs. Universal design principles are a transfer towards inclusion promising improved solutions for people with diverse abilities. Nevertheless, often in design practice universal design becomes only a formulation among designers. This claim is supported by statement from Mustaquim, (2015) claims an existing theoretical guidelines as design principles often fail to result in real universal design. In addition, Mustaquim, (2015) also claim there is no standard ways to evaluate the impacts of customer needs in universal design principles exist in product performance.
In order to develop a structural standard to evaluate and improve universal design principles implementation in design process. A systematic approach is needed in order to develop a concept meet the customer need. Bertonecelli et al., (2016) state that TRIZ offers a systematic approach for problem solving requires creativity abilities when translating the recommendations offered by inventive principles and standard inventive solutions into the specific domain of the problem.

2.4. TRIZ Application in Universal Design

There is lack of evidence showing TRIZ application for universal design in design practice. A study by C. M. Yang et al., (2010) proposed a TRIZ-based innovative product design process that incorporates universal design principles (UDP). This study highlights the importance of approach in order to develop concrete product concept throughout the product design and development with creative and systematic problem-solving procedure. However, broad application of TRIZ has attracted numbers of researcher to integrate other method with TRIZ. Most of them are in new product development (NPD) and innovation area.

Ko, (2017) state that abstract conceptual design is a critical activity during the early phases of product development, most creative ideas will be generated in this process. Deimel, (2011) found that TRIZ has more similarities than differences with classical design methods. Yang, Kao, & Liu, (2012) stated that an innovative problem-solving method should be the one that can eliminate conflict or contradiction in a problem effectively and efficiently and help generate innovative solution. And TRIZ is the one to serve this purpose well. Study by Chang et al., (2016) found that TRIZ has a strongly positive effect on an ability to analyse problems, and to generate, select, and execute a strategy. TRIZ also increased the creativity in designed products, including ability to develop and implement novel ideas.

3. Results and Discussion

3.1. Summary of Literature Review

In summary, visually impaired person relies on haptic sensory in order to develop spatial perception. Perceptual information spatial perception is important for brain during interpreting and recognizing using sensory naturally. However, for visually impaired person, other senses will be more dominance than visual. Haptic sensory trigger the haptic memory when assessing the necessary forces during interacting with familiar objects. That particular behaviour is identified as haptic exploratory procedure. In order to meet diversity of user needs factor by difference in age, capabilities, social and cultural background, an approach of universal design is introduced. Unfortunately, there are some drawbacks shown by the existing universal design practice. Designer mostly use subjective approach in proposing universal design during conceptual development. There is no structural design guidelines or framework in universal design approach.

3.2. Summary of Literature Review

Therefore, a theoretical framework is constructed base on the summary of the literature review, as per shown in Figure 3 below. There is a gap for potential research of HEP consideration towards UDP in universal design practice. From literature, it shown that there is no standard design practice available for designers to applied since most of the guidelines merely theoretical and shown no positive results in actual practice [16]. Therefore, a potential TRIZ integration with UDP is propose in order to develop a structural approach of universal design. However, in order to achieve universal design among visually impaired person, HEP consideration is needed as knowledge support system for TRIZ – UDP as problem solving tools for universal design.
4. Conclusions
For further study, the focus of the research in constructing contradiction matrix from properties of object interpreted by haptic exploratory procedure (HEP) and developing correlation matrix between universal design principles and 40 TRIZ inventive principles. A validation through concept design is needed in order to verify the HEP contradiction matrix and UDP-TRIZ sheet in order to prove this theoretical framework. Findings from this study will contribute a structural universal design tools to develop design with consideration of visual impaired person haptic exploratory procedure. HEP contradiction matrix and universal design tools integrated with TRIZ 40 inventive principles is proposed to replace existing theoretical guidelines as design principles often fail to result in universal design.

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