

Title	CPS技術統合による感性評価の研究 インタラクティブ・コスチューム・デザインの事例
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## 論文の内容の要旨

Revolutionary changes have been occurring at an unprecedented rate in the fields of clothing. The interactive clothing, a topic on which there is little previous research, an evolutionary branch of smart clothing in the field of information science, which emphasizes the function of social symbols that mutual interaction or communication between the wearer and their environment based on the integration of information science and traditional clothing. Combining Cyber-Physical Systems (CPS) with a clothing engineering design to input a certain physical signal into clothing, the interactive clothing can output a certain social symbol that people or clothing environment can perceive and generate corresponding interaction. This kind of social symbol is the expression form of the interactive clothing as the interactive medium for people to interact with the environment. With the gradual integration of the internet of things (IoT) and CPS into people's daily life and the growing development of smart textile technology, interactive clothing will play an increasingly important role in future interpersonal communication and interaction.

Despite its impressive track record in smart clothing research and development, we still have to confront with several current research dilemmas or development bottlenecks from correlative humanities science and information technology respectively. Researchers have generally focused on high-tech approaches to implementing smart clothing design with multifunction. Nevertheless, the complex sociological attributes of clothing, i.e., its interactive symbolism and properties of emotional expression, design hierarchy and design aesthetics and other aspects should not ignore.

The overall purpose of this research is to bridge the gap between CPS applications in the field of information science and emotional evaluation in the field of humanistic science, to minimize the unbalance between humanistic emotion and wearable smart technologies for interactive clothing

innovation, to investigate how the transformation could realize from information to knowledge in the process of interactive clothing design, to establish a basic framework of design principle and design evaluation criteria system for interactive clothing, and suggest practical implication for interactive clothing design.

To attain the above objectives, the study will answer one Major Research Question: What happened to the interactive clothing when the social semantics of transform from the information stage to the knowledge stage in the architecture of CPS? In addition, three Subsidiary Research Questions (SRQ), according to Soft System Methodology, i.e., the “WHY”, “HOW” and “WHAT” as follow. SRQ1: Why does the R&D of interactive clothing worn in daily life need to integrate smart technology with emotional design and humanistic evaluation simultaneously? SRQ2: How is the technology transformation could realize between the signals in the field of information physics and the symbols in the various dimensions of humanity and society? SRQ3: What does the design principles of interactive clothing should be valued in the context of CPS’s growing prosperity?

The practical research of this topic was started in 2012; progressive results were getting during three stages. The first stage was in 2013, two types prototype of infant’s smart clothing were developed. As a result, two of China’s utility model patents have granted, which illustrates the feasibility and rationality of this study’s entry point. The second stage is the interactive couple clothing prototype, which is a kind of clothing media that can transfer some interpersonal relationship, completed in 2016-2017. Further, the diversified interaction results have achieved through a three-piece set of interactive parent-child clothing prototype in the third stage from 2017.

In theoretical research, by literature review and literature integration approaches, the psychology, sociology and design hierarchy of clothing, as well as data-information-knowledge-wisdom (DIKW) theory and CPS architecture are deduced and summarized from the perspective of humanities and technology respectively to analyze the humanistic and technical attributes of interactive clothing. The Cyber-Physical-Clothing Systems (CPCS) model of the technical development process of interactive clothing is created, and the validity of the CPCS model is verified by the method of prototype development and Kansei engineering evaluation. Through Kansei evaluation, the design elements and evaluation criteria of interactive clothing are also extracted. The results found that the research on interactive clothing should integrate the two opposing perspectives of humanities and technology, and bridge their gap from an interdisciplinary perspective in the process of prototyping and evaluation.

The main differences between the contents of this study and previous studies by other scholars are as follows: (1) New prospective, that is, this study pioneered a new field of smart clothing research, namely interactive clothing; (2) New approach, that is, this study introduces CPS technology into clothing development from the approach of art design; (3) New system, that is, a research framework for interactive clothing was initially established.

The main original contributions of this study are as follows: (1) The concept of interactive clothing was

pioneer defined; (2) From the perspective of humanities and technology respectively, the models of studying the attributes of interactive clothing are built to guide the research path; (3) Integration of CPS, DIKW and other information technology and theory to create a Cyber-Physical-Clothing Systems architecture model to guide the prototype development of interactive clothing ; (4) The 18 “C” Design Principles of interactive clothing are revealed; and (5) The criteria framework of interactive clothing design evaluation is created to encourage the object of evaluation to develop in the right direction and objectives. Therefore, the knowledge framework associated with interactive clothing is preliminarily established in the category of Knowledge science.

**Keywords:**

Interactive Clothing, Cyber-Physical Systems (CPS), Cyber-Physical-Clothing Systems (CPCS), Evaluation, Design

**論文審査の結果の要旨**

本博士論文は、デザイン諸相の I T 化を踏まえ、ファッションデザイン分野における新しい動向であるスマートクロージングについて、特にそのインタラクティブな性質に着目したデザイン研究のフレームワークを提案し、実装事例とその評価実験の結果をまとめた研究である。

スマートクロージングの体系化では、衣料に限定されない幅広い範囲で、詳細かつ充実した文献研究を行うことで、当該分野の知識基盤を構築するに至っており、そのうえで未来社会におけるファッションデザインの価値創造に通じる議論が重ねられている。知識科学として、今まであまり応用されていなかったファッションデザインでの展開を論考し、**Cyber-Physical System** のピラミッド状の構造として示している。また、衣服の役割について、従来のファッションデザイン研究のアプローチでは到達しえなかった総合的なデザイン観を示し、技術・社会・意味の変化の過程と人間の欲求段階を対比することで、新規なモデルを構築している。

異なる機能を発揮するように計画された三つの実装事例では、人間の感性を重視した独創的なインタラクティブな機能を有したファッションデザインに挑戦しており、実際の社会に展開可能なスマートクロージングの開発についての実践的な研究により、具体的で有用な知見が得られている。評価実験での分析は、学術的に価値があり、基準を満たしていると認められる。

今後、ファッションデザイナーと I T 技術者が協力しあうことで、人々の生活の質を高め、社会をより豊かにするスマートクロージングの方向性を示唆しており、社会的な意義が十分に示されている。このことから、本研究の成果が将来的に社会に浸透する方向性が

十分語られている。知識創造プロセスとして、有用性があると感じられる。

スマートクロージングは、産業振興と直結する重要なコンセプトであるだけでなく、技術的に急速な進展が見込まれることから、当該領域においては人材を育てる教育の先進性が期待されている。本博士論文で示された研究知見は、デザイン教育の現場を牽引するに足る、十分に有意義なものであるといえる。

「以上、本論文は、ファッションデザインにおけるスマートクロージングについて知識科学の視点で論考、及び、実装・評価したものであり、学術的に貢献するところが大きい。よって博士（知識科学）の学位論文として十分価値あるものと認めた。」