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【論文の内容の要旨】

Smart home consists of various kinds of Internet of Things (IoT) devices connected to the private house that cooperatively provide inhabitants (users) with proactive services related to comfort, security and safety. Examples of services include 1) manipulation of lighting and temperature based on time and context, 2) reminder service of user’s schedules by using the nearest output device, and 3) device organization to realize surveillance system. However, current smart homes are developed mostly from the viewpoint of technical capabilities, where users have to decide how the connected devices are going to serve them. They may have to setup the devices based on the available functionalities and specifications of the devices, and also have to alter their living styles according to the role of each device. Besides, most devices can only provide simple services independently. Thus, cooperation among the devices is important.

On the other hand, human-centric approach, which centered on humans’ need to enhance their living experience, is an important technological paradigm where services are provided anywhere and anytime based on situation. Smart home abiding this approach should cooperatively maximize fulfillment of quality of life (QOL) for individual users subject to personal constraints. In this respect, the devices are bound to enable communication of information, and their operations are coordinated to deliver services cooperatively via a sequence of device actions called a plan.

Due to personalization and automation, a number of problems have to be solved. First, a means of automatic binding between loosely coupled devices depending on services delivered have to be devised, as manual setup is impractical. Secondly, coordination of devices needs to generate complex plans, without requiring manual specification of sub-plans. Besides, issue of over-constrained goals during service provisions that arises from flawed or contradicting specification from multiple users should be considered. Apart from that, low training data in general environment setting for individual identification should be addressed.

The aim of this research is to establish an integrated system for the human-centric smart home (HcSH) that provides personalized service through loosely coupled devices automatically. This research modularizes the overall system into three modules, which are human identification (HIM), automated planner (APM), and semantic reasoner (SRM). HIM helps select the appropriate QOL, SRM binds the devices by associating them with planning components, which are then used by APM to generate plans for device coordination to maximize QOL fulfillment.

Chapter 1 gives the introduction and design motivation.

Chapter 2 presents the related works and literature reviews, as well as justifications relevant to this thesis.

Chapter 3 deals with HIM, which is realized via face identification. For face identification, problems faced are heavy computational load and insufficient learning data. The solution is to use transfer learning to handle data issue while being able to build generalized face model. For face model refinement, active learning is implemented. Experimental results show the method is competitive in terms of accuracy and computational cost compared to current state of the art.

Chapter 4 presents APM, where planning via solving Constraint Satisfaction Problem (CSP) is laid out. CSP in planning is declarative without requiring prior specification of sub-plans, and can handle variables of larger domains. Due to the high possibility of having over-constrained QOL as in practical cases, CSP planner cannot fulfill all of them. An example is a contradicting TV channel request from 2 persons. Optimization through weighted CSP is therefore used to maximize QOL fulfillment. Experiments on weighted CSP shows that the method is capable of performing optimization while generating complex plans.

Chapter 5 is on SRM, where knowledge representation is constructed by Web Ontology

Language (OWL) description logic. It models knowledge on home and building layout and device functionalities. OWL is used because it is decidable and that it is endorsed by World Wide Web Consortium (W3C). We deal with case studies based on further inference on building state as an important example to discuss the applicability of the proposed method, and demonstrate the use of building ontology. This is followed by automated device binding and the method to generate basic planning components of rules in automated planning. Finally, an extension to robot complex planning is provided to demonstrate how it can be easily extended.

Chapter 6 demonstrates the applicability of the HcSH, which integrates all three modules through its implementation in a prototype smart home with 5 rooms, which houses 2 persons. Various tests are performed to show that the generated plans are near optimal without redundancy. The system is also shown to be scalable given increasing amount of devices. Case studies show that the system can perform well even under short time threshold.

Finally, chapter 7 summarizes the thesis. Future vision of the work is also laid out, which is to implement it as a community-centric system.