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Acceptance and Usage of Innovative Healthcare Service for the Elderly People: A System Dynamics Modeling Approach

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Abstract. The issue of robots applied to healthcare for improved quality of healthcare is a new service style but amongst literatures for technology acceptance in the past, the nonlinear or interactive relationships between variables neglected by traditional statistic analyses result in technology acceptance behavior not completely clarified. In this study, we depend on system dynamics to develop the healthcare robot user behavior system model which includes pre-adoption, post-adoption and social diffusion. The study contributes to provide critical references to service providers, robot designers, and policy makers of the government.

Keywords: Healthcare Robot , Technology Acceptance Model, Telecare, System Dynamatics

1. Introduction

In Taiwan, 75.9% of elderly people having suffered from chronic or serious diseases. To offset insufficiency of the traditional medical care, the development of technical medical equipment has become a critical scheme probably solving this issue. In this regard, there has been technically medical equipment such as robot applied to services of healthcare-related fields, that reduce a hospital's manpower and improve efficiency of patient healthcare [1].

The Healthcare Robot System (HCRS) based on healthcare robots has been developed in Taiwan. The design of this system is intended for robot-based self-measurement of an elderly person's or a patient's personal physiological information at home and this information delivered to a hospital via Internet for evaluations, consultations and recommendations of a user's health conditions. The healthcare robots provided more bed facilities for other patients and reduced the cost of medical insurance by 10% every year [2].

There are four principal characteristics in the healthcare robot system. (1) Innovative technical product and service. (2) Purpose of long-term healthcare. (3) Elderly people as main users. (4) Human-computer interaction.

The healthcare robot system, however, includes acceptance & use (pre-adoption), continuance usage (post-adoption), influential factors and interactions, which constitute the entire user behavior system. In order to clearly understand user behavior of healthcare robots, we analyze the user behavior system from the viewpoint of system dynamics and investigate interactive and feedback relationships between variables of different dimensions. The study with development of a system dynamic model is intended for purposes as follows:

- Find acceptance behavior, factors affecting users' continuance usage and effects in between from relevant theories and literatures.

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- Develop the system dynamics model of elderly people's user behavior for healthcare robots based on the viewpoint of system dynamics; draw variable-related causal loop diagrams to graphically analyze relationships and interactions between variables.

2. Materials and Methods

2.1. Theories Regarding Technology Acceptance Behavior

For a new healthcare service such as healthcare robot, the theories or models such as Theory of Reasoned Action(TRA), Technology Acceptance Model(TAM), Theory of Planned Behavior(TPB),Unified Theory of Acceptance and Use of Technology(UTAUT), Social Cognitive Theory(SCT) and Diffusion of Innovation Theory(IDT) frequently applied to researches of the technology acceptance behavior have good interpretability [3].

From literatures in connection with the technology acceptance behavior, some common variables classified into five dimensions: (1) psychology: perception, attitude, intention, anxiety, trust, etc.; (2) personal trait: innovativeness, experience, self-efficiency, etc.; (3) society :subjective norms, government support, etc.; (4) industry: facilitating conditions, trialability, trust, etc.; (5) product: interface, design, personality, etc.

The Expectation Confirmation Theory (ECT) has been extensively applied into researches of post-adoption behavior[4,5,6] .An elderly person under effects of multiple factors in the technology acceptance model will make a decision prior to accepting healthcare robots and determine satisfaction by comparing expectation and perceived performance[7]. As an important variable to forecast something continuously used or loyalty.

The variables related to the healthcare robot user behavior system herein are categorized to 5 principal dimensions wherein. The relationships between these variables collected from relevant theories, researches or literatures, are summarized in Table 1.

Table 1: variables in a technology acceptance and usage behavior

Dimension	**IV**	DV	Influence	Dimension	**IV**	DV	Influence
PT	Innovativeness	Intention	Positive	Psychology	Attitude	Intention	Positive
PT	Innovativeness	PEU	Positive	Psychology	Intention	AB	Positive
PT	Innovativeness	PU	Positive	Psychology	PU	Attitude	Positive
PT	SE	PEU	Positive	Psychology	PU	Intention	Positive
PT	SE	PU	Positive	Psychology	PU	PE	Positive
PT	SE	AB	Positive	Psychology	PU	Trust	Positive
PT	SE	TA	Negative	Psychology	PU	Satisfaction	Positive
PT	Experience	SE	Positive	Psychology	PEU	Attitude	Positive
PT	Experience	TA	Negative	Psychology	PEU	PU	Positive
PT	Experience	PEU	Positive	Psychology	PEU	Intention	Positive
PT	Experience	Attitude	Positive	Psychology	PEU	Trust	Positive
PT	Experience	Intention	Positive	Psychology	PEU	PE	Positive
Industry	Trust	PU	Positive	Psychology	PEU	Satisfaction	Positive
Industry	Trust	PEU	Positive	Psychology	PE	Attitude	Positive
Industry	Trust	Intention	Positive	Psychology	PE	Intention	Positive
Industry	FC	PEU	Positive	Psychology	PE	PEU	Positive
Industry	FC	Intention	Positive	Psychology	TA	Intention	Negative
Industry	Trialability	Attitude	Positive	Psychology	TA	Attitude	Negative
Product	Observability	Attitude	Positive	Psychology	TA	PEU	Negative
Product	Interface	PEU	Positive	Psychology	TA	PU	Negative
Product	Interface	Attitude	Positive	Psychology	TA	SE	Negative
Product	Design	Attitude	Positive	Psychology	Confirmation	Satisfaction	Positive
Product	Personality	Attitude	Positive	Psychology	Satisfaction	CUI	Positive
Society	SN	Intention	Positive				
Society	SN	PU	Positive				
Society	GS	Intention	Positive				

PT：Personal Trait; AB：Actual Behavior ;PU：Perceived Usefulness; PEU：Perceived Ease-Use; TA：Technology Anxiety; SN：Subjective Norms; GS：Government Support; SE：Self-Efficacy; FC：Facilitating Conditions; PE：Perceived Enjoyment; CUI：Continued Usage Intention

2.2. System Dynamics

System Dynamics (SD) developed by Professor Forrester, Massachusetts Institute of Technology, in 1950's refers to the dynamic, nonlinear and feedback concept for complicated social phenomena and emphasizes interactions between variables of the system[8]. Based on systematic thinking for all events, this thinking mode contributes to insight into correlations between variables. SD emphasizes intra-system interactions and dimensions composed of dependent variables wherein the causal loop diagram as the foundation of SD assists an administrator to clearly control key factors.

2.3. Establishing the System Dynamics Model

In the casual loop diagram, the correlations between variables expressed by their casual relationships are connected with arrows (origin: influential variable; terminal: affected variable). A positive feedback loop featuring variables changed in the same direction allows them to grow increasingly [9].

Based on SD, the entire system comprises three parts, pre-adoption, post-adoption and social diffusion behavior, and is constructed with influential factors in five dimensions wherein those variables and the influence relationships between variables are collected from relevant theories, researches or literatures. The casual loop diagram of the HCRS is shown in Figure 1.

3. Results and Discussions

As shown in Fig. 1, the HCRS model based on the casual loop diagram of SD which are described as follows. (1) Personal trait: In view of the positive effects of innovativeness on PU, PEU and BI, a user with high innovativeness will accept healthcare robot products or services more easily than other persons.

Furthermore, a user with high self-efficiency inclines to accept and adopt healthcare robots because of effects of self-efficiency on perceived usefulness, perceived ease of use and actual action. (2) Society: With positive effects on PU, BI and SN are referred to as social pressures by which an individual care about comments of reference groups such as peers, family members and physicians for decision-making. Government support also has a positive relationship with behavioral intention. To make users realize the efficiency of using healthcare robots, the government presents influential people as good role models, giving subsidies or tax cuts to enterprises, or subsidizing users to purchase products for increased adoption intention.[74] This reduces negative influences such as perceived cost barriers.

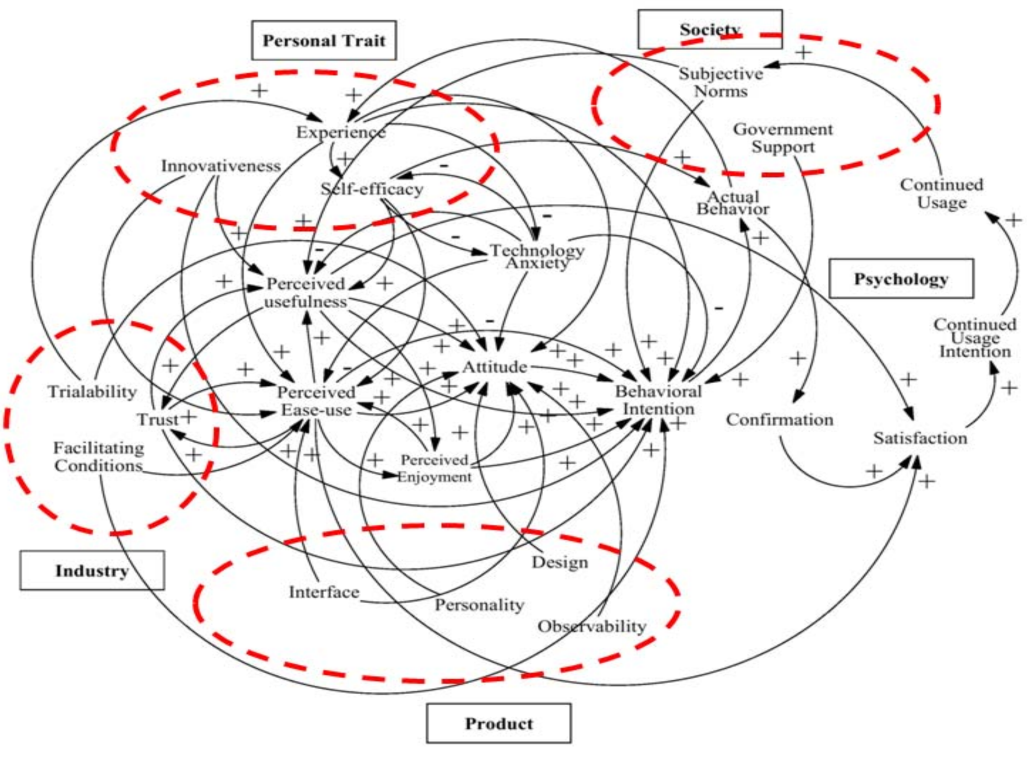

Fig. 1: Causal loop diagram of HCRS

(3) Industry: The experience and attitude of most elderly people without experience of using HCRS can be positively influenced by the industry. The PEU, BI and post-adoption satisfaction can be positively affected by facilitating conditions, i.e., supports and resources supplied to elderly people by the industry.The dimension of industry that the positive feedback loops exist in trust and PU or PEU.

(4) Product: There is a positive relationship between a human-computer interface and PEU or attitude. There is a close relationship between observability and innovation diffusion for efficiency of one product, for instance, the efficiency of a healthcare robot conveniently observed and its characteristics easily described will be in favor of generation of positive attitude. These potential users who detect other prior users' praise are also willing to try the new healthcare system [10].

The dimension of psychology is located at the center of Fig.1. For attitude and intention, the positive factors are PU, PEU and PE, the negative ones are TA . It can be seen from the entire behavior system how these factors are influenced one another for development of actual acceptance and user behavior.

In this regard, perceived enjoyment is more critical to IT user behavior than perceived usefulness [11,12] and positively affects perceived ease of use, attitude and intention. It is noteworthy for product designers and service providers that a positive feedback loop begins both with perceived enjoyment, which is positively affected by perceived usefulness and perceived ease of use, and with perceived ease of use.

The satisfaction positively affected by expectation confirmation, PU and PEU has positive effect on intention for continuance usage of HCRS. This study argue that the social norm maybe gradually developed with more and more users constantly influencing other people. Based on the IDT, the diffusion process for one innovative product in a social system is characteristic of self-sustaining with the product users accounting for a certain percentage of the total population.

4. Conclusions

This study explain the innovative healthcare service user behavior system and cover pre-adoption & post-adoption behavior and social diffusion .The nonlinear, dynamic and feedback relationships between dimensions or variables of the user behavior system based on SD for development of HCRS make up insufficiency of traditional statistic analyses in which nonlinearity and interactions are not considered. The system dynamics model describes how people's psychology and consequent behavior are influenced by multiple factors and how their behavior has effect on a society and finally constitutes a circular system, and is very meaningful to service providers, robot designers, and policy makers of the government.

Despite the structure and interactive relationships between variables of the healthcare robot user behavior system described herein, the intensity of variables affecting one another still unknown and not simulated deserves to be further studied for clear relationships between variables.

5. References

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