IoT Nudge: IoT Data-driven Nudging for Health Behavior Change

Yugo Nakamura
y-nakamura@ait.kyushu-u.ac.jp
Kyushu University
Fukuoka, Japan

Yuki Matsuda
yukimat@is.naist.jp
Nara Institute of Science and Technology
Ikoma, Japan

ABSTRACT

This paper presents an Internet of Things (IoT)-based concept called "IoT Nudge", which aims to induce continuous healthful behavior changes through interactions between human users and IoT devices, including smart sensors and actuators. More specifically, IoT Nudge systems aim to establish self-reflection loops in which our daily behaviors are reflected in the IoT devices around us. The changes in the presentations of those IoT devices promote self-awareness and provide us with opportunities to improve our lifestyle habits. To reconfigure poor behavior into good behavior, the IoT Nudge provides three functions: (1) automatic tracking of a user's lifestyle habits using IoT sensors, (2) playfully reframing the user's daily activities into other more healthful representations based on analogies, and (3) delivering real-time ambient feedback through reframed representations from IoT actuators that encourage self-reflection. Herein, we describe our conceptual model of IoT Nudge and introduce three prototype systems aimed at promoting health improvements: *fit2plant*, *eat2pic*, and *brush2music*.

CCS CONCEPTS

• **Human-centered computing** → **Interaction design**.

KEYWORDS

Internet of things, Nudge, Behavior change, Interaction design, Persuasive technology

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1 INTRODUCTION

In the information society of today, where accessibility to a variety of temptations such as junk food and information overloading have proliferated, living a healthier lifestyle while maintaining self-control under all circumstances has become difficult for many people. As a result, there is an urgent need to find ways to promote healthy daily habits while still considering systematic errors in human thought processes and cognitive biases [2]. In our projects, we aim to bridge this gap by exploring the interaction potentials of the Internet of Things (IoT) devices. The "IoT Nudge" concept (1) integrates "nudge" mechanisms [1, 6] to guide people to healthful choices and behaviors without coercion, and (2) utilizes IoT systems [3, 4] to connect the physical and digital worlds via smart, context-aware, everyday objects and devices. In this short paper, we present our IoT nudge approach.

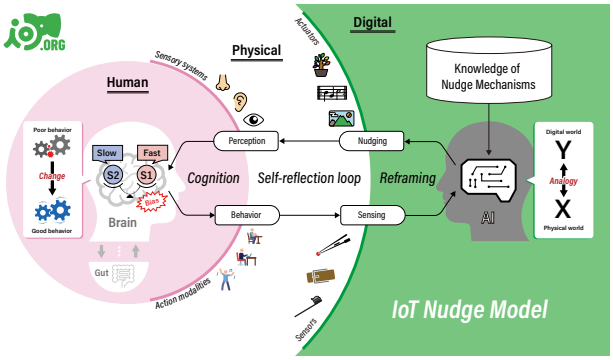

Figure 1: Overview of IoT Nudge model

2 IOT NUDGE MODEL

Fig. 1 shows an overview of "IoT Nudge", which aims to establish a self-reflection loop in which our daily behavior is echoed in the IoT devices around us and within which the changes in the representation of IoT devices playfully promote self-awareness and urge users to improve their lifestyle habits. IoT Nudge has three core processes: (1) automatic tracking of user lifestyle habits using IoT sensors, (2) playful reframing of user daily activities into other representations based on analogies, and (3) providing real-time ambient feedback through reframed representations on IoT actuators to encourage self-reflection. Through daily interactions with IoT systems around us, these IoT-based "nudges" aim to increase healthy behaviors and reduce unhealthy actions. In the next section, we present specific examples of IoT nudge systems that work in three scenarios: promoting regular exercise, eating a balanced diet, and stimulating good oral hygiene.

3 IOT NUDGE SYSTEM EXAMPLES

3.1 fit2plant: Promoting regular exercise

Fig. 2 shows the interactive design of *"fit" to "plant"* (*fit2plant*) system, which is designed to reconfigure user exercise habits by observing their "exercise" behaviors in the physical world and reflecting them as digital "plant growth". Here, we focused on developing an analogy between their exercise behavior and a growing plant. The fit2plant system is composed of a sensing component that is based on an inertial measurement unit (IMU) sensor mounted on a fashion belt setup to monitor exercising behavior (A and B) and

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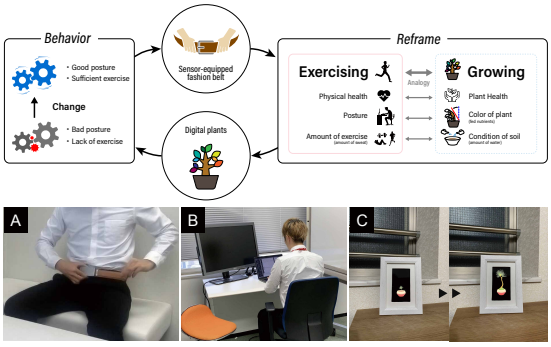

Figure 2: Interaction design of fit2plant

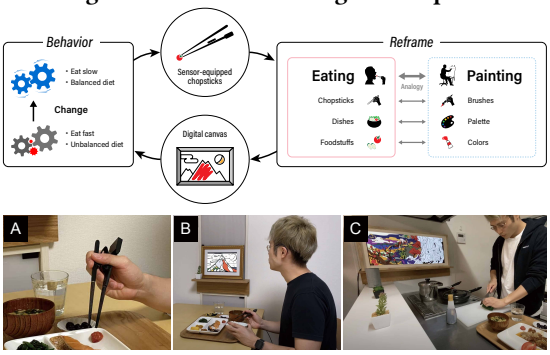

Figure 3: Interaction design of eat2pic

intervention components using context-aware digital plants (C). User posture and daily exercise amounts are reflected in the posture and growth amounts of the digital plants. These interactions are designed to nudge the user into increased awareness of his or her daily posture and promote exercise awareness.

3.2 eat2pic: Promoting balanced diet

Fig. 3 shows the interactive design of *"eat" to "pic"* (*eat2pic*) [5] system, which aims to reconfigure user eating habits by observing their eating behaviors in the physical world and reflecting them in a digital "painting". Here, we focused on developing an analogy between eating and painting. The eat2pic system is composed of a sensing component based on a micro-camera and an IMU sensor-equipped chopstick setup (A), and an intervention component consisting of two digital canvases (B and C). Together, these allow users to enjoy their mealtimes while watching colors appear on a digital canvas landscape painting.

The colors of the foods consumed by the users are reflected in the landscape painting placed on two context-aware digital canvases. However, the way the colors are applied will change depending on how the user eats. For example, if the user rushes to eat a meal, multiple colors will mix in one area, and the landscape appearance will degrade. These short-term painting nudges reflect the user's behavior through the course of one meal (B), while the long-term painting reflects his or her eating habits over a weeklong period (C).

3.3 brush2music: Promoting good oral hygiene

Fig. 4 shows the interactive design of *"brush" to "music"* (*brush2music*) system, which is designed to reconfigure user teeth brushing habits

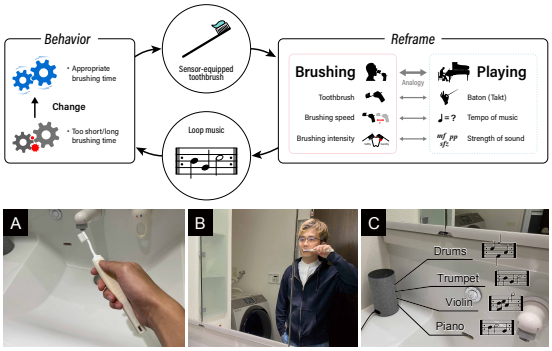

Figure 4: Interaction design of brush2music

by observing their "brushing" behaviors in the physical world and reflecting them in digital "musical instruments". As in the eat2pic and fit2plant systems mentioned above, the goal is to create an analogy between brushing their teeth and playing musical instruments.

The brush2music system is composed of an IMU sensor-equipped toothbrush and calm technology-based intervention components centered on a smart speaker. The brush2music system provides an experience that makes user feels as if they are creating loop music by brushing their teeth properly. The brushing speed is reflected in the music tempo, and the brushing intensity is reflected in the sound strength.

On the first day, only simple drum rhythms are played. However, after about a week, users can enjoy beautiful loop music harmonies mixed with the sounds of drum, trumpet, violin, piano, and other instruments. These elements are intended to nudge his or her brushing habits (such as speed, intensity, and brushing targets).

4 FUTURE WORK

In the future, we will conduct user studies of each IoT nudge system to investigate the impacts of long-term interactions between users and those systems on healthful behavior changes. We also aim to systematize the IoT Nudge concept further and build a framework that bridges the domains of ubiquitous computing and behavioral economics.

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