Computational Community: A Procedural Approach for Guiding Collective Human Behavior Towards Achieving a Flourished Society

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Abstract. In this paper, we propose a procedural framework to design collective human behavior for overcoming serious social problems, such as environmental sustainability and human well-being. The framework integrates respective persuasive services installed in urban cities for pervasively guiding people's behavior towards achieving a sustainable and flourished society. Each persuasive service manages a small piece of human behavior. Each persuasive service is represented as a basic block in our framework; the basic block specifies how to change a piece of an aspect of people's daily behavior. A service designer connects these basic blocks and coordinates them procedurally by developing a program using mobile phones. The approach enables persuasive services that are pervasively and seamlessly embedded into our daily lives to continuously guide people's behavior towards ideal sustainable human behavior.

Keywords: Crowdsourcing · Collective human behavior · Human well-being · Procedurality · Semiotic meaning of the real world

1 Introduction

Our society urgently needs to solve a variety of social issues. For example, in the modern lifestyle, people consume a large amount of natural resources, which makes our future life unsustainable. Ubiquitous computing technologies dramatically improve the efficiency of natural resource usage, but the improvement is limited in the future if we only take into account technological aspects. We need to change our behavior and improve our daily lifestyles to reduce the usage of natural resources [10]. Changing human behavior is crucial to achieving a sustainable society. There are several alternative ways to change human behavior. One of the typical approaches is to use social norms or public policy. A government may conduct public campaigns to promote the sustainable lifestyle necessary to maintain its country's wealth. However, the approach will only be able to improve the average behavior, and some people may not change their behavior. The phenomenon is very problematic because free riders who do not change their behavior may receive benefits without making efforts, and other people will consider their behavior unfair. Finally, most people may stop contributing to the campaign. Thus, the social situation will become worse.

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As shown in [14], these traditional approaches may also reduce some people's happiness because the approach cannot be customized for them and they may feel a strong inconvenience from being guided through the social norms or public policies. The decrease in their happiness becomes a strong reason to increase the number of free riders. To achieve a sustainable and flourished society, the direction of their respective behaviors should be customized according to their current situation and preferences to increase the happiness of all. Ubiquitous computing technologies can be used to design persuasive services that offer customized ways to guide people's behavior without reducing people's happiness.

In past research studies, many persuasive services incorporating ubiquitous computing technologies have been proposed, and they successfully demonstrate changing human behavior [9]. However, these existing services focus on only one piece of an aspect of people's behavior, such as stopping smoking, encouraging tooth brushing or reducing unsustainable behavior. When using these technologies in urban cities for guiding people's behavior towards achieving a sustainable society, we need to consider how to influence a citizen's behavior seamlessly through ubiquitous computing technologies incorporated in urban cities. The persuasive technologies can be embedded everywhere in cities and can influence citizens' behavior in their respective places. However, there is currently no way to connect these technologies to guide people's behavior according to their current situations and locations.

In this paper, we propose a procedural framework to design collective human behavior. The framework integrates respective persuasive services for pervasively guiding people's behavior towards achieving a sustainable and flourished society. Each persuasive service manages a small piece of an aspect of a respective citizen's behavior. The persuasive service is represented as a basic block in our framework; the basic block specifies how to change a piece of an aspect of the citizen's behavior. A service designer connects these basic blocks and coordinates them procedurally. The approach enables persuasive services that are pervasively embedded into our daily lives to guide citizens' behavior continuously towards achieving ideal sustainable behavior.

Our approach particularly focuses on guiding collective human behavior because most serious social problems are categorized as collective action problems. Thus, a piece of an aspect of a citizen's behavior specified in a basic block can be performed by any other citizen. To encourage potential citizens to perform actions specified in basic blocks, we adopt a crowdsourcing concept, where the actions can be performed by any citizen, and they are selected according to the policy defined in the crowdsourcing infrastructure. When a specified action is complex, it can be decomposed into several small sub-actions, and some citizens can perform the respective sub-actions independently.

We also provide a case study to demonstrate our proposed framework, which is named *Collaborative Music Construction*. The case study demonstrates how our proposed framework can successfully guide collective human behavior. *Collaborative Music Construction* supports a community in collaboratively composing a new piece of music. People have different skills relevant to the composition of music, so *Collaborative Music Construction* defines different types of basic blocks, where actions specified in the basic blocks in *Collaborative Music Construction* require different skills and knowledge. Thus, each person who has different skills and preferences can become

engaged by choosing their favorite sub-actions. We are currently implementing a prototype system of *Collaborative Music Construction* and will show some experiences with it using the case study.

The remainder of the paper is organized as follows. Section 2 presents our proposed framework and the *Collaborative Music Construction* case study, which adopts the framework. Section 3 describes the future direction of our research. Using virtual reality techniques with an HMD device can enhance the immersiveness of our persuasive experiences. We provide one case study to investigate a possible future direction to enhance the proposed framework. In Sect. 4, we discuss some research related to our approach. Finally, we conclude the paper in Sect. 5.

2 Guiding Collective Human Behavior with Procedurality

2.1 Overview

Crowdsourcing is a promising approach to exploit our social power and to enhance our human ability and possibilities. Crowdsourcing will become increasingly important in modern society as a means to direct a collective of people to perform micro-tasks, which are small, simple tasks that can be completed within a short time. The roles of crowdsourcing have recently expanded into a variety of new areas, such as citizen science, civic engagement, and political campaigns, and will continue to increase in importance for modern society [18].

Live coding, also referred to as on-the-fly programming, just-in-time programming and live programming, is a programming practice that adopts improvised interactive programming [2, 17]. Additionally, TopCoder's crowdsourcing-based business model, in which software is developed through online tournaments, is a promising approach to developing programs [5].

Our approach is also based on a crowdsourcing concept similar to TopCoder, but each piece in a program can be developed based on a live coding concept to program human behavior. Each piece in a program developed by the crowd specifies how people behave. If they behave as expected, they are asked to perform the next action according to the program. This section presents the basic concept and demonstrates a case study of the concept to show its effectiveness.

2.2 Computational Community

Recently, there have been major debates about whether GDP (Gross Domestic Product) is an appropriate index to measure the wellness of each country because the index focuses only on measuring economic aspects of the social wellness—how rich people in the country are—rather than measuring human happiness in the country.

Our activities in modern countries emphasize pursuing economical wealth; however, increased wealth has not improved our happiness. Although information technologies have contributed to optimizing our economy and resource consumption, the question of

whether information technologies improve our well-being has not been well investigated. The *Computational Community* concept that we propose enables social communities to be collectively guided without decreasing human well-being.

In contemporary society, there are many rules documented for the public, such as laws, but there are also many tacit rules, such as social norms, that limit our activities. People behave based on the rules. In other words, each person designs a sequence of his/her activities that are suitable in the current situation based on both explicit and implicit rules and decides which activities he/she performs. A community that contains multiple independent persons determines their collective activities based on such rules.

In this paper, *Computational Community* is a social infrastructure that efficiently guides collective human behavior by expressing human activities based on rules specified as procedural forms—like "codes" in computer programming. *Computational Community* makes it possible to optimize our collective activities and to facilitate communication among people by proposing a sequence of appropriate activities based on the current situations and rules represented as procedural forms. *Computational Community* can be used to propose the best times to ride trains and to suggest what garbage is recyclable. The concept aims to make our society more flourished by having each person consider only small desirable activities that can be achieved with his/her small effort. Because *Computational Community* explicitly guides desirable human behavior, people can allocate their mental resources to more important issues.

2.3 A Basic Framework

The rules are usually defined to achieve some purpose. There are many purposes, from abstract to concrete, defined by the rules. For example, there are many types of laws, such as a concrete law to determine a national budget and an abstract law to ensure our mental safety. In *Computational Community,* a rule that is typically expressed as a constraint should be translated into a procedural representation, but the procedure needs to be agreed upon by all people in a community. Currently, we have adopted a crowdsourcing concept that exploits the power of the crowd as an underlying infrastructure of *Computational Community.*

In the *Computational Community* framework, we define each concrete goal as a mission, and a guiding process to achieve the mission is divided into the following two phases, as shown in Fig. 1. The first phase is the *defining process phase*, and the second phase is the *executing process phase*. In the *defining process phase*, the crowd repeatedly refines a rule defined as a procedural form to achieve a target mission. The process is similar to the process for collectively developing computer programs in TopCoder. The developed procedure consists of a set of small procedures, like typical computer programs. Each small procedure is a *basic block*. A *basic block* is an executable task that can be completed by the crowd. The process to achieve the target mission is defined and visualized as a sequence of *basic blocks*. The phase can define not only a simple sequential process but also a complex process including inputs, outputs, branches, and loops, like traditional computer programs. The target mission can be achieved by completing the *basic blocks* defined in a procedure by the crowd in the *executing process phase* based on a crowdsourcing concept.

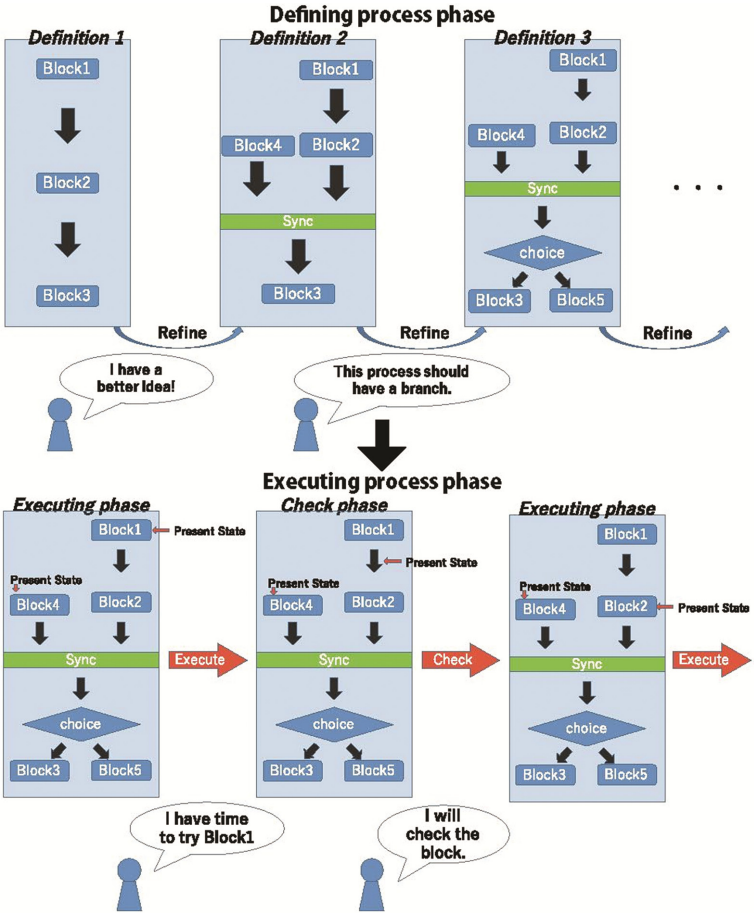

Fig. 1. Computational community framework

2.4 A Case Study: Collaborative Music Construction

A case study named *Collaborative Music Construction* is the composition of a musical piece by community members through achieving a mission. Composing a musical composition depends on not only each person's talent but also the rules or theories developed by past great music composers. People can usually compose a standard musical composition to follow the rules and theories. This case study demonstrates the *Computational Community* concept because composing musical compositions collaboratively requires defining a goal as a mission that creates a good musical composition, and the process to create the musical composition can be divided into several submissions that can be assigned to the crowd. In the current framework, the *defining process phase* is simplified and defined by a single person, not the crowd. The framework named *Musico* has been developed as an Android application written in Java, as shown in Fig. 2.

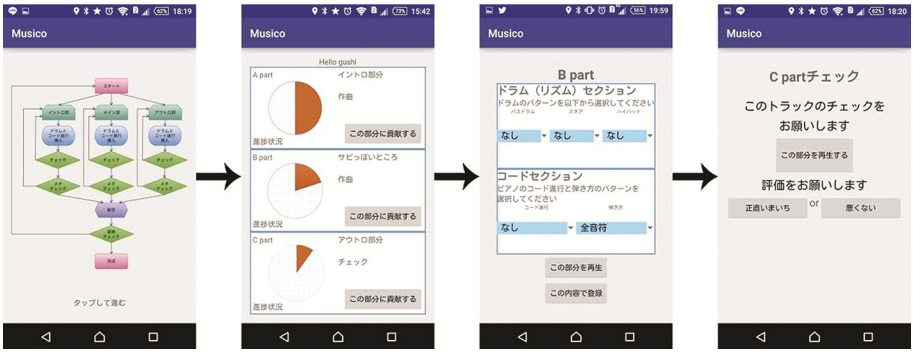

Fig. 2. Musico screenshots

A Scenario Using Musico: To demonstrate the effectiveness of the *Musico* framework, we have developed the following scenario, as shown in Fig. 3. We assume that *Kinoa*, who does not have the professional knowledge and skills to compose music, wants to create a musical composition. She decides that the main instrument in the music composition is the piano and creates the melody. However, she does not know how to create other elements of the musical composition. Thus, she decides to use *Musico*. *Musico* helps her to create a concrete musical composition as follows:

i. When *Musico* is started by *Souya*, a procedure to achieve a mission defined by *Kinoa* appears on the display of *Souya*'s mobile phone to confirm the process of how to achieve the mission.
ii. The next screen enables *Souya* to select which part he can contribute. The screen presents a graph showing which parts are currently completed. He can skip any tasks to complete the part when he does not want to perform them. Because the next possible *basic blocks* that can be performed are shown on the screen, he can contribute to another task, such as a task to check the quality of the part when he has enough free time.
iii. A *basic block* to create a part allows *Souya* to easily attach drum and accompaniment patterns through the drop down menu. If he satisfies a selected pattern, he confirms his update and the update is stored in the system.
iv. When a community member composes a part, another community member can check the quality of the part. He can decide whether the part is good or bad. If he considers the part to be bad, the currently composed part is rejected and other community members need to create the part again.
v. Community members repeat step (iii) and step (iv) until three tracks for which quality checking has been completed have been created for the part. If the quality checking of three tracks is completed or a timeout occurs, the composition process becomes the *meta-check* step.
vi. In the *meta-check* step, a community member listens to the available tracks and votes for one of them. If the number of votes for one of the tracks exceeds the specified threshold, the *meta-check* step is completed for the part.

vii. If the *meta-check* steps of all parts are completed, the application combines these parts as one music composition, and all tracks are delivered to *Kinoa*, who ultimately checks whether she is satisfied with the tracks.

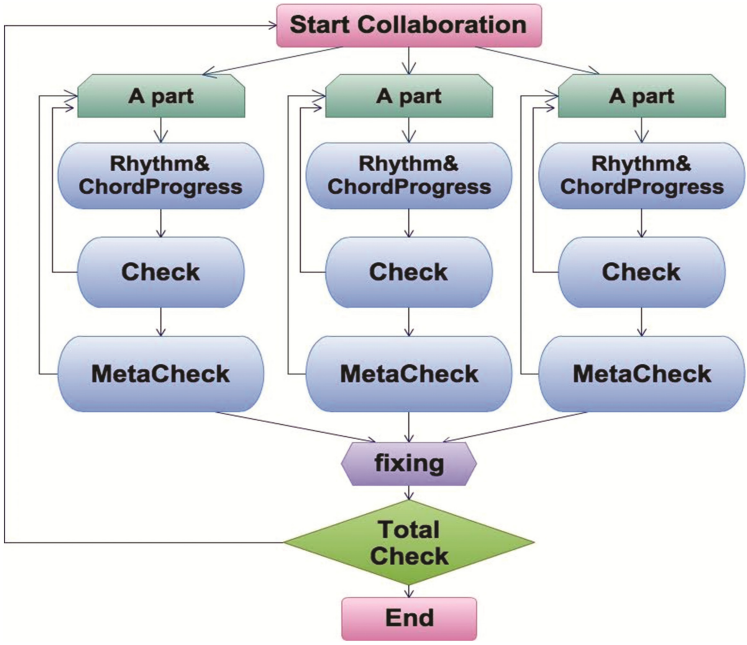

Fig. 3. Procedural representation of the scenario

Experiment with Musico and MusicoSolo: We conducted an experiment using the role-playing based method according to the scenario described above. In the experiment, the *process defining phase* was simplified because the experiment was conducted to validate the feasibility of the *process executing phase* in *Computational Community*. We have developed two applications in the experiment. One is *Musico* introduced above, and the other is a Java-based Android application named *MusicoSolo*, which implements a traditional crowdsourcing-based service to evaluate the feasibility of the *Computational Community* framework. *MusicoSolo* asks one member of the crowd to create all parts of a musical composition by himself from the given melody.

In the experiment, we recruited 11 Japanese university students (7 males and 4 females) for three days. After they used both applications for creating music compositions, they were asked to complete a questionnaire. The participants mainly responded that *Musico* was better. The insights extracted from the experiment are summarized below:

- The quality checking of a musical composition was fun for the participants and motivated them to use *Musico*. Many participants answered that they could learn the others' ideas through the quality checking process.

- The repeated quality checking process improves the quality of a musical composition, but it may create only popularized music compositions and may reduce the possibility of creating creative and niche compositions that require a higher level of creativity.

In the scenario, a user needs to show strong creativity to achieve the mission, so the quality checking task may motivate the user because the task requires less creativity; ultimately, the created musical composition becomes less creative. The most interesting insights extracted from the experiment are that the creativity level required to achieve the mission is essential to motivating the crowd and that the creativity level design appropriate to maintain the curiosity of most of the crowd is an important issue in designing a mission in *Computational Community*.

2.5 Design Implications

Incentive: The results of the experiment show that *basic blocks* in *Computational Community* require different types of human motivation to be performed. Thus, a person who designs a *basic block* needs to consider which incentive is appropriate. In particular, the required creativity level heavily influences the motivation to perform the *basic block* because curiosity is a strong internal motivation for humans. If the creativity level is appropriate for most of the crowd, they will be willing to perform the *basic block*, but if the creativity level is too high, only few members of the crowd will be interested in performing it. On the other hand, if the creativity level is too low, most of the crowd will need a monetary reward to perform it.

Ethical Issues: The framework may guide people maliciously or unintentionally according to the proposed missions. For example, people may be immorally guided to perform undesirable activities if strong external motivations are offered. However, it is not easy to decide which activity is undesirable. The decision depends on the ideologies in each community. In *Computational Community*, there is no central organization to ultimately decide on the ethics of the guiding process, so it is an interesting issue how a peer-to-peer-based distributed organization resolves ethical issues collaboratively.

Modeling: Currently, our *Musico* framework visualizes *basic blocks* like a visual programming language. However, the modeling may not be appropriate for tangibly defining the procedural form to represent rules in the *defining process phase.* We need to consider a new style to create a procedural form for *Computational Community*. The insights from the live coding research community may heavily influence the progress of the direction.

3 Future Direction: Enhancing the Semiotic Meaning of the Real World

In this paper, we discussed how to influence collective human attitudes and behavior based on a computational approach. The proposed framework offers each community member a possible sequence to show how to coordinate his/her activities. One of the

pitfalls of the approach is that he/she may not perform a specified activity due to his/her lower motivation regarding the activity.

To overcome the pitfalls, we conducted an additional experiment to motivate people by enhancing the semiotic meaning of the real world [4]. In the experiment, we justify the usefulness of the integration of the virtual world and the real world and show that the enhancement is a promising approach to motivating people. In the experiment, we have developed two types of real role-playing games (RRPG), where a player pretends to be a character defined in the game in real spaces, such as rooms and streets. RRPGs are categorized as pervasive games [8], but the player plays a fictional role in the game.

Figure 4 shows the first RRPG, which does not use virtual reality (VR) technologies. In the game, a player considers that he/she assumes that there is a fictional object in the real space, and the space is a fictional space representing the story defined in the RRPG. The player needs a strong imagination to play the game in the fictional world. On the other hand, the second RRPG adopts VR technologies and a player wears a head-mounted display. In the hybrid real world, a player can actually see a fictional object by rendering its 3D image in the real space, as shown in Fig. 5.

Fig. 4. RRPG without VR technologies

After playing the games, we asked the participants to complete questionnaires. In total, 68 participants completed the questionnaires in this experiment; 66 participants said that "*The second RRPG offers more immersive experiences than the first RRPG*". Some of them claimed that there were some occasions in which the reality of the fictional objects was lost. We asked them to provide the reasons for their response, and one of them told us, "*I could not touch the fictional objects incorporated in the real world.*" Additionally, another one said, "*There is no smell on the objects, and it is really unnatural.*"

The results of the experiment indicate that the immersiveness offered through the integration of the virtual world and the real world is a promising approach to increasing human motivation, but it is essential to maintain the reality of the fictionality

Fig. 5. RRPG with VR technologies

incorporated into the real world. Incorporating fictionality into the real world is also important in designing procedural steps of human activities in our proposed framework because some actions need to be designed as fictional events to motivate people [15]. In the next step, we need to integrate the enhancement of activities through fictionality as shown in this section to extend the proposed framework presented in Sect. 2.

4 Related Work

A new approach, community-based mobile crowdsourcing [11, 12], in which people voluntarily contribute to helping other people anytime and anywhere using mobile phones, has been reported. The task required is usually trivial and, consequently, can be performed with minimal effort and a low cognitive load; we call the small task a micro-task. This approach offers a new method of developing services to address serious collective action problems, such as achieving social sustainability from the bottom up as an underlying social infrastructure. For example, the location-based, real-time, question-answering service *MoboQ* is built on a micro-blogging platform, through which people help each other with minimal effort [7]. Using *MoboQ*, end users can ask location- and time-sensitive questions, such as whether a restaurant is crowded, whether a bank has a long waiting line, or whether any tickets remain for an upcoming movie at the local cinema—i.e., questions that are difficult to answer with ordinary Q&A services.

Bogost argues that the unique meaning-making strategy of games is a digital rhetoric called procedural rhetoric [1]. Video games are relatively new media, and many people discuss their rhetoric. Game designers typically want to express their ideas and feelings about conceptual visual elements in games without relying on stories, imagination, sound, etc. Instead, they want to convey meaning only through the game's processes. Procedural rhetoric offers a strong persuasive effect because the rhetoric is bidirectional, whereas other rhetorical media are unidirectional. Video games allow us to interact with

digital rhetoric through game controllers, but we have recently been able to use tangible devices to interact with the imaginary world, such as Microsoft Kinect[1] and Nintendo Wii[2]. These devices enable us to interact with digital rhetoric very naturally without distinguishing it from the real world. The current technological advances in computing thus allow us to seamlessly incorporate digital rhetoric into the real world through procedural rhetoric representing digitally mediated virtuality.

Most recently, digital marketing and social media practitioners have adopted this approach under the term gamification [3, 6]. The idea is to use game mechanics to make a task entertaining, thereby engaging people to conscientiously complete tasks. Adding *batches* and *leaderboards* is a typical approach to achieving gamification. In [13], an approach to use deeper game mechanics, such as coordinating several challenges to enhance crowdsourcing services, is proposed. That approach is very close to the approach proposed in this paper, but it does not support live programming, which is important for the practical deployment to pervasive persuasive service in urban cities.

5 Conclusion

In this paper, we presented a procedural framework to guide collective human behavior. Our framework integrates several persuasive services to guide human behavior anytime, anywhere in urban cities. We also provided a case study named *Collaborative Music Construction* that adopts the framework to demonstrate the effectiveness of our proposed approach. Our framework will be used as an underlying social infrastructure to guide human social behavior towards achieving a flourished society.

In the next step, we are considering extending our proposed framework to take into account the enhancement of semiotic meaning in the real world. *Gameful Digital Rhetoric* is a promising approach to support the future direction described in Sect. 3, and integrating *Gameful Digital Rhetoric* [16] with our proposed framework is also a promising step to systematically develop new types of persuasive services.

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