Coralog: Use-Aware Visualization Connecting Human Micro-Activities to Environmental Change

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Abstract
This paper describes the goal, design approach and specification, and preliminary use test of a use-aware ambient media called *Coralog*. Coralog is a widget that detects the duration of a user's computer idle time (i.e. leaving the computer on without active usage) and communicates the energy consumption behavior through the visualization of the health of coral reefs. By occasionally consulting the non-intrusive widget, users can immediately acknowledge the impact of their computing behavior on ecosystems. Therefore, the goal of this application is to make the public become aware of the connection between their everyday activities and global climate change, which will educate them about the formerly unseen effects that their actions may have and potentially lead to a sustainable living.

Keywords
Eco-visualization, Ambient Media, Awareness, Sustainability, Conservation Behavior, Persuasion

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction

Global warming has become an important topic among academics, businessmen, governmental bodies, and non-governmental organizations. According to environmental scientists, climate change such as the increasing air and ocean temperatures around the globe is primarily caused by human activity on a micro level [4]. Although everyday human activity has led to environmental change, people do not easily change their behavior unless they see the immediate impact [9]. To visualize the real-time impact and provide engaging feedback, digital media has emerged as a means to persuade and educate the public. Aiming at ultimately modifying people's behavior, we have designed an ambient medium, called Coralog, that creates an awareness of the connection between human micro-activities and global climate change.

Related Works

For Human-Computer Interaction researchers and designers, the emerging field of *eco-visualization* has become a challenging and interdisciplinary topic [e.g. 1, 3, 9, 11]. Holms described that eco-visualization *"offers a novel display the real time consumption statistics of key environmental resources for the goal of promoting ecological literacy"* [7].

Approaches to eco-visualization can be grouped into three main categories for comparison: 1) how human behavior is tracked, 2) how data is represented, and 3) what form/style of visualization is used.

Collective Tracking vs. Human Micro-activities:
The domain of tracked human behavior is either within collective context or of a single individual activity. Odom and others' project theme addresses the electricity and water consumption at college dormitories. It visualizes the amount of the entire energy consumption at each building promoting the competition among the residences of each building [11]. *700 oaks and counting* uses the building control technology tracking the flows of the energy and shows the entire energy consumption at one building [7]. In contrast, some projects focus on a single activity, such as the energy consumption of one appliance [5], driving habit [3], and the consumer's choice of a single item [16].

Pure Data vs. Conversion through a Metaphor:
Some eco-visualization projects focus on the accuracy showing the exact number and unit of energy consumption [7, 11]. Others alternatively represent data employing metaphors easily understood by ordinary people who are not familiar with the scientific measure. Ford Motor Co. announced new dashboard design called *Efficiency Leaves*, which grows more when a driver maintains environment-friendly driving habits [3]. *700 oaks and counting* emphasized the number of trees than the pounds of emitted CO_2. Swedish designers' *Power-Aware Code* is the example of more abstract representation. A translucent cable surrounding an electronic cord glows red if more power is being used [5]. A TV campaign by Australian government represents the CO_2 emission from home appliances as the number of black balloons, which is aesthetically powerful [17].

Informative Application vs. Ambient Media:
According to the purposes of the visualization, the form or style is different. If the visualization presents rich information requiring users' intentional attention, it exists as graphical interfaces on a public installation [7,

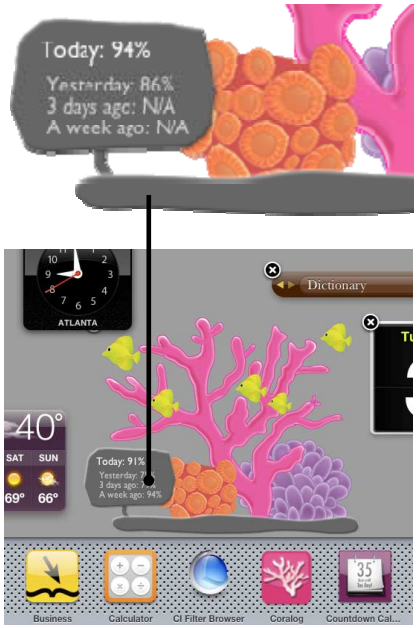

figure 1. Coralog Deployed on Dashboard

15] or as a website [11]. The informative application focuses on delineating real data into the charts and graphs borrowing the style from scientific visualization rather than abstract or artistic expression. In contrast, ambient media intend not to force the user to walk up to a device but rather to receive the information at a glance from a distance [5].

Concept of Coralog

Many eco-visualization projects focus on the entire usage of the general energy categories (such as electricity or water consumption) and on the aggregate residential populations rather than on individual behavior. The look-and-feel is typically either too scientific, depicting the accurate numerical amount of consumption or employs metaphorical images which do not directly relate to the environmental agenda that is brought up. In contrast to such previous works, we have designed a non-intrusive application for Macintosh OS X users called Coralog (figure 1).

Coralog is a widget that does not force people to watch it intentionally, but rather guides them to use it habitually. It visualizes:

- The effect of a single person's micro-activity on environmental change. Idle computer usage is considered as one cause of CO_2 emissions.
- Scientifically-related images of real environmental change that are typically hidden from our everyday lives. We chose coral reefs as a visual theme, which are currently being destroyed by the rapid increase in the amount of CO_2 dissolved in the ocean [6].
- How human being's micro activities are related to the environmental change in macro sense such as "Global Warming" and a particular symptom such as "Coral Reef Change" in the ocean (see figure 2) [6, 14]. The emphasized boxes in Figure 2 explain the connection visualized in Coralog.

Consequently, the design goals of Coralog are to:

- Increase the awareness of energy consumption and its related effect: human micro activities actually and ultimately affect the environmental change.
- Encourage people to change their behavior: specifically, turning off or into sleep mode their computers when not in use and therefore people can reduce their electricity consumption.

Design Approach

Coral Reef

Coral reefs are one of the most sensitive ecosystems to long-tem climate changes that are triggered by human activity[2]. Increasing CO_2 levels and temperature changes caused by burning fossil fuels are considered main influences on global climate change (figure 2) [10]. The vast majority of these increases are likely due to unsustainable activity choices and general human indifference to local and global ecosystems. Global warming likely results in destroying coral reefs and their ecosystems. Elevated sea surface temperatures can cause coral to turn into white and are referred to as "bleached." Moreover, coral skeletons can be weakened by higher temperature and chemical reactions (see figure 3) [8]. The side effect of population decreasing is also critical. Reef fish can be exposed to danger because of the lack of suitable reef shelter. As reef fish stocks decline, the local ecosystem can be quickly collapsed. However, findings from ecological experiments show that fish and coral are likely to recover if the environment anomalies persist

for less than a month, but the sustaining stress can cause physiological damage that may be irreversible [12].

Visual Representation

We represent the three major aspects of coral reef change in Coralog: coral bleaching (vivid color to bleaching), coral population decreasing (size of coral, the number of branches: large to small), and reef fish disappearing (five to none). For the dynamic visual effects, we adopt the three different coral species with the reef fish; Tree coral (*Scientific Name: Paralemnalia sp.*), Bubble coral (*Plerogyra sinuosa*), Tube coral (*Tubastrea aurea*), the reef fish, Yellow Tang (*Zebrasoma flavescens*). To depict the gradual change, we produced ten different images (figure 3).

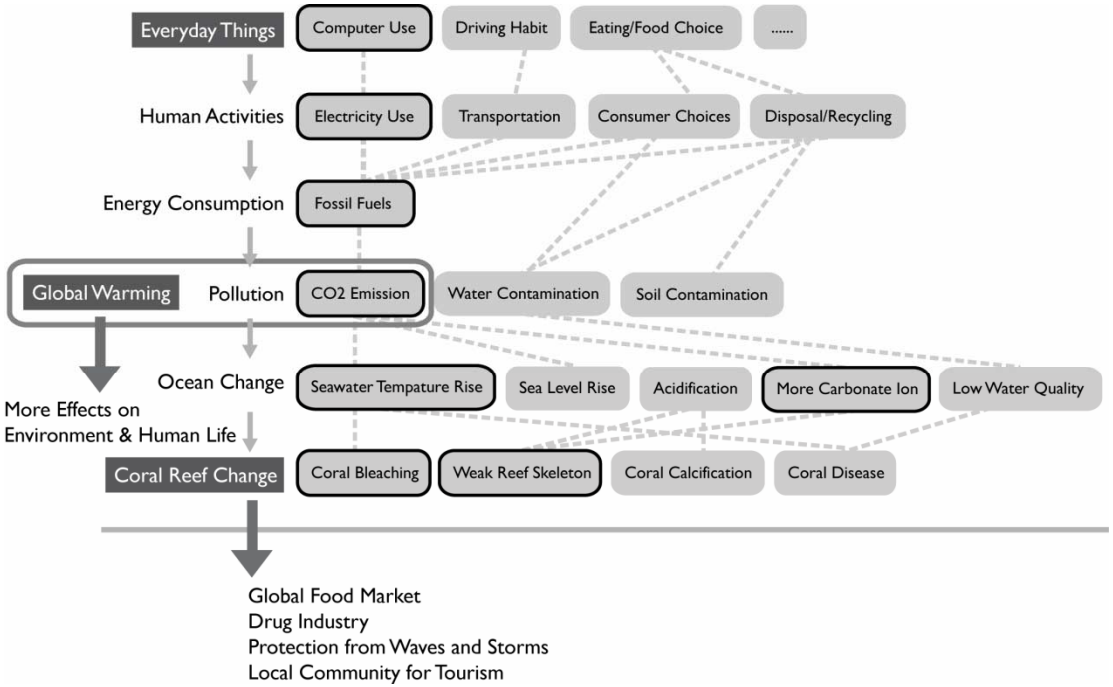

figure 2. Human Micro-activities to Global Warming to Coral Reef Change

Coralog shows the instantaneous coral's health status through the simulated coral reef images and the textual representation of the overall health. The real-time result of energy waste is represented: the color and shape of coral reefs change according to users' activity (figure 3). Text information also shows the coral condition of the previous days – yesterday, 3 days ago, and a week ago (figure 1).

Data to Visualize

We define "idle time" as a period of at least five minutes for which there occurs no mouse or keyboard input. Besides idle time, Coralog also detects the entire computer usage time and calculates the ratio of the two, which decides the condition of coral reefs (equation 1). Also we devised to reflect the performance of the past: the coral reef change is formulated relatively to the daily change rather than the absolute ratio (equation 2). That is, if the ratio of idle time to total computer usage time is smaller than the previous day, the coral reef will become healthier despite the increased accumulated idle time. It also matches the reversible nature of coral reefs.

C_d = Condition of coral reef on the "d"th day
(100: completely healthy, 0: dead)
I_d = Idle time on the "d"th day
T_d = Total computer usage time on the "d"th day

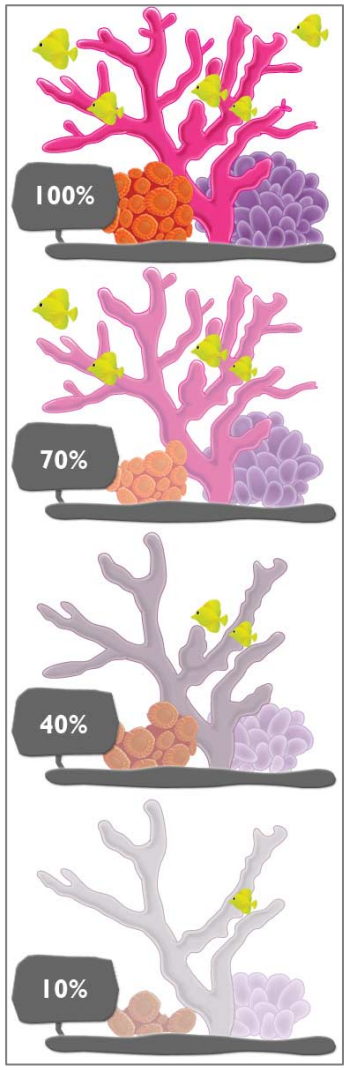

figure 3. Gradual Change of Reef Set According to the Health Condition

$$C_1 = 100 - \frac{I_1}{T_1} \times 100$$ (**equation 1.** when d=1)

$$C_d = C_{d-1} \times 0.3 + \left(100 - \frac{I_d}{T_d} \times 100\right) \times 0.7$$

(**equation 2.** when $T_d \neq 0$ if $T_d = 0$, then $C_d = C_{d-1}$)

User Experience of Widget

Macintosh widgets typically provide non-intrusive information with little or no input from the user or should perform simple tasks that a user may want to do often in the limited space available on the Dashboard [13]. They also require relatively small use of CPU, which matches our energy consumption theme. Users consult the hidden application occasionally and easily whenever they bring up their Dashboard. They can quickly notice the health of coral reef and potentially be more aware of their energy consumption behavior.

Preliminary User Testing

As a part of an iterative and user-centered design process, we have performed a preliminary test for one week. We aimed at obtaining feedback on the design and function of Coralog from six participants who are very computer literate and regular widget users: IT-related professionals and computer science/HCI/design students. Here are several interesting findings and comments.

On Visualization

Although they understood that the coral reef change represented the idle time, participants wanted to know more accurate data of electricity consumed.

- Participant 1: *"I want to see how much electricity I'm leaking or how my effort to reduce the idle time effects the real world."*
- Participant 2*: "If there is something that shows the historic logs then ... maybe I can see the pattern of my usage."*
- Participant 3: *"I'd like to see my usage everyday, not just "yesterday", "three days" and "a week ago"*
- Participant 4: *"It would be better if the thresholds of bleaching become more extremely and distinctively."*

On Persuasion

The one-week testing period was not long enough to expect the substantial change of usage habit. However, we found that Coralog had motivated one user to modify his behavior.

- Participant 1: *"To revive the weakened coral reefs, I tried to make my laptop sleep when I leave."*
- Participant 3: *"It made me feel bad for using my computer."*
- Participant 4: *"When I found the reefs getting healthier, my guilty feeling was relieved."*

Discussion

Humans are capable of modifying their behavior but are far more likely to do so if the cost of their current behavior is well understood [9]. Since people are currently unable to immediately understand the effect that their habitual behavior has on environmental issues, they do not recognize the urgency of changing the way they live [9].

Rather than being a task-oriented application and accurate representation of quantitative activities,

Coralog suggests a new way of interaction design for sustainable living. By focusing on one simple human habit (keeping computers idle) that is easily fixed without determination, we visualized the actual and immediate symptom of an unconscious human micro-behavior: coral reef change.

Future Work

We plan to add some dynamic animation on top of the current coral reef images. This will allow the users to experience a more-polished widget. In order to make users recognize their usage pattern, a history-tracking function will be added. To satisfy users' request to see scientific data, the estimated actual power consumption will be added as an advanced feature. Next, we will perform a formal evaluation to see how Coralog encourages good energy conservation practices in computer use.

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