Computer-Driven Experiences with Familiar Objects

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ABSTRACT

By applying the tenants of pervasive computing (PvC) in conjunction with the philosophy of speculative design, "Computer Driven Objects with Familiar Objects" (CDEFO) aims to not only to digitally and physically express our emotional attachment to objects, but also pose questions about how we interact with computers and objects. The results of CDEFO will be 1) an easily implementable software suite using Python, Arduino, and NFC, and 2) a series of art-like "user experiences" using the software suite that will hopefully lead to reflection about the future of PvC as a form of Human Computer Interaction (HCI), primarily as it pertains to the manifestation of the sentimental values we store in objects that transcends their utilitarian function (i.e. a teddy bear being a comforting object during difficult times, or a receptacle for happy memories). Content for the user experiences could potentially come from anyone who has sentimental attachment to an object, and the curation of this content will represent the bulk of project development time. The software suite will include pre-coded Python scripts (to be run on a Host Machine) and a C++ library/driver sketch (to be upload to an Arduino). The only work that any potential end-user will do is writing/planning the experience and scanning it to an NFC tag. In the same vein, I'd like to encourage others to use the library on their own to write their own experiences, and thus plan on writing extensive documentation covering its functionality. I want the software suite to be the toolkit through which people will explore the emotional attachment to their own possessions. Being an embedded computing project, the costs aren't negligible, but they likely won't exceed $250, including equipment.

INTRODUCTION

The beauty of the human imagination is that we can take physical objects and apply abstract ideas to them. We give objects sentimental value, value that is derived solely from that object's existence in a time and place. A souvenir from an amusement park reminds us of good times shared with family and friends. What if we took the emotional information stored in those objects and did something with it? Imagine if picking up that souvenir opened a photo album of your trip. Through muscle memory, our minds often associate certain motions/objects with routines. For example, some might associate picking up a ceramic mug with the act of brewing coffee. What if we could seamlessly integrate computers into this muscle memory? Imagine all our social media logging out and the ELMS homepage popping up when we pick up our pens. What I propose is a way to meld the emotional and functional information our minds store in objects to create one immersive user experience (an object paired with it's physical manifestation once on the receiver) using the principles of pervasive computing.

Thanks to the advent Near-field communication (NFC) technology, we now possess a straightforward way to store information in an object and communicate it to a computer. The only problem right now is that the computers don't necessarily know what to do with the information once they receive it. Therefore, what I propose is via a software suite consisting of an Arduino-Compatible C++ library and Python scripts that supports a wide range of commands via NFC, so that myself or more

inspired individuals can demonstrate the power of familiar objects. As of right now, pervasive computing has really only been used to sell us products, so I feel it's time to consider harnessing the power of PvC as a method of expressing emotions and feelings, as a cathartic, evocative experience.

PROJECT DESCRIPTION

One of the results of CDEFO will be an ".h" file (C++ library file extension) that you will #include in an Arduino sketch that *writes* to the NFC tags, that you #include in a sketch that *reads* from the NFC tags, and Python scripts that will integrate over serial to execute commands on a host machine. For the driver to read a line of input, the line needs to be formatted in some predictable way (i.e. you need to be tell where in the line the commands, parameters, etc. are located). As such, I will need to make a standard formatting for the NFC command lines that everyone who uses my library will need to conform to. Documentation for custom scripts and drivers will be provided, but at a lower priority.

Once I have the software written, I will need to fabricate the NFC sensor apparatus as well as embed programmed NFC tags into everyday objects so that I can actually "begin" CDEFO by diving into the "Speculative Design" part. The apparatus will consist of an Arduino Uno + Adafruit NFC "shield" in a custom enclosure, powered through a host machine's USB port. Tagged objects that have already been programmed beforehand will be placed on top of the enclosure, which will excite some sort of behavior out of the Arduino as it iterates through the commands. Example behaviors that would run on the host machine would include recording/playing a media file, or opening/closing a particular group of related programs. The relationship between these will be emotional in nature (e.g. sad music, sad movies, favorite video games when you're feeling sad) For behaviors that are facilitated through the Arduino alone, I would need to create circuits/modules that interface with it specifically (i.e. make a circuit that dims light fixtures), I plan on fabricating those as I curate experiences from other people. Ideally, each module would have its own function in the C++ library. As I run my experiences and gain input, I can continue to iterate and change aspects about the individual experiences/modules to ultimately answer the question, ".

HISTORY

The entire technical portion of CDEFO is more or less founded on the idea of pervasive computing (PvC), as taught in our HDCC105 lecture. Using computers without it ever being apparent that you're using computers. I was inspired by "The Computer for 21st Century," and the idea that laptops and desktops as interfaces into the world of information are simply holdovers until technology gets advanced enough that it can integrate seamlessly into our world. As Mark Weiser puts it, computers at this point are, "approachable only through complex jargon that has nothing to do with the tasks for which people actually use computers." While a lot of the hardware bottlenecks from Weiser's time have been dealt with, information scientists are still 1) figuring out ways to make scalable solutions, 2) creating proper interfaces (NFC, Wi-fi, LTE, etc.) that can handle hundreds of devices per room, and 3) finding ways to only acquire the most relevant, error-free data to operate on. Covering the first point, there are complications involving the reliability of connections in a wireless network, due to the sheer volume of devices and the consequential difficulty that comes with coordinating them, and the fact that frequency

band real-estate is relatively small and highly variable (Gardellin, Das, Lenzini). Secondly, PvC doesn't really have a standard interface for devices to communicate. In a survey conducted on current middleware solutions, they found that the best solutions are those that are simplistic, so any abstraction is very minor and not prone to bugs, giving developers one less thing to worry about (Raychoudhury, Cao, Kumar, Zhang). Lastly, the relevant data is entirely dependent on context and PvC don't have the benefit of users manually inputting relevant data. For example, PvC deployments in bookstores will be entirely different from those in nursing homes (Xue, Pung, Sen), and they need to be able to decide which data is valuable enough to keep and how to use that data (O'Neill, Conlan. Lewis).

As a result, I've decided to roll with a watered-down perception of PvC. Instead of a large network of independent devices, I will have one single user access point that communicates over NFC, with all of the contextual information already programmed onto the tag. Essentially, I'll be spoofing an actual pervasive computing environment in such a way that I can focus primarily on my research question.

Now, CDEFO isn't just a technical demo of what PvC might look like in the future, there is also this very prominent speculative component to it, from which I'm drawing the majority of my inspiration from Human Computer Interaction(HCI) research (a field which Mark Weiser was heavily involved in) and the Speculative Design paradigm. HCI being the study of how people interact with computers and Speculative Design being the practice of asking "what if" questions that open debate about the future that people want. CDEFO aims to intersect both concepts, particularly, where my "what if" question is, "what if PvC environments could express your emotions?" and it triggers reflection on the objects we cherish, why we cherish them, and effective ways of expressing these emotions. Similar experiments have been done by prominent researchers in HCI like Elise van der Hoven with "Towards a More Cherishable Digital Object," and works by speculative/critical designers like Anthony Dunne and Bill Gaver serve as valuable references and inspiration as CDEFO progresses.

SIGNIFICANCE AND DISTINCTION

Now, building off of the earlier, more basic examples, what if someone were having a bad day, and picking up their beloved stuffed animal automatically ordered insomnia cookies and ice cream, put on sad music, put on mood lighting, and picked up in the middle of a Netflix binge? There are obviously the practical applications of this in that it'd be a cool and inherently useful/beneficial interaction between this emotionally valuable object and a PvC environment; however, as an exercise in speculative design, exploring the ways through which we experience our emotions and handle them is useful when it comes to the future of PvC and the direction we want to take when it comes to the development of these systems.

A similar project that has a similar tone is Bill Gaver's Table Cloth. Called, "The History Tablecloth," it is a flexible screen-printed table cloth with electroluminescent farming a grid of glowing lace. When objects were left on the table their imprints would be illuminated by the cloth and would persist for many hours. Much like CDEFO aims to be, it is a reflection of objects beyond simply what they are *for*. It explores a design that emphasizes aesthetics, reflection, and interaction over pure function,

and much like what CDEFO aims to do, it illustrates alternatives to traditional views of technology as nothing more than a utilitarian tool while also putting forth the idea of permanence and the persistence of those emotional connections that inform our interaction with them.

This is what PvC means to me. The ability for me to manifest my moods and feelings via ubiquitous computers without necessarily focusing on their pure functional viability. As of right now, PvC is being implemented in the form of Internet of Things (IoT) devices such as Amazon Echo or Google Assistant that really only serve to make consuming easier. In my case, a computer driven experience that is controlled by a familiar object, I'd like to show this idea to other people to explore what their objects mean to them, and whether they'd be willing for PvC to take a turn in this direction.

EXPERTISE AND SKILLS

Things I Know:
Coding in C++
Bash Scripts
Serial protocols
Other computer science concepts (input/output redirection, forking processes, etc.)
RC Circuits
3D Modelling

Things I Don't Know:
How to setup a build environment for a C++ library
Maintaining a concise and comprehensive database standard
How to give CLI access to an Arduino
The Speculative Design Paradigm
Established works in the field of Human Computer Interaction

APPROACH

Due to the speculative design paradigm, I need to ask myself what attaches people to their objects. I can come up with digital/computer driven "design probes" and postulate how they will either amplify or create a desired emotion (i.e. will this curtain that looks like rippling water trigger nostalgia?) to answer my main research question, "what if PvC environments could express your emotions?" On top of the emotional response, I can also gauge immersion in the experiences themselves. Even if the experiences can't trigger the emotional responses I hope, they should at least be of high quality and should elicit some sort of positive reaction. Input from the audience of this nature will likely inform the direction which PvC and HCI take in the future.

WORK PLAN AND TIMELINE

Week 1:
- Setup the build environment for the C++ library
  - Find an Arduino NFC library to build off of
- Host Machine platform decided on
- Acquire the Adafruit NFC Shield and ~10 NFC tags
- One or two user experiences curated
  - Having ordered the parts for the necessary modules

Week 2-3:
- Find more user experiences (continuous)
- Start working on the C++ library (2 days)
  - Try to at least get down function prototypes that apply to the user experiences gathered so far.
- Establish serial communication between the Host Machine and the Arduino (3 days total)
  - Can I get the Arduino to run a command on Windows/Linux/Unix? (1 day)
  - What are the limitations of data transmission over USB? (2 days)
- Establish a reliability standard for the NFC communication (2 days)
  - How often does communication drop?
  - What is the effective distance?
  - Etc.

Week 4-5:
- Find more user experiences (continuous)
- Start and finish the database standard that the NFC's will use to store commands (4 days)
  - How long do the lines need to be?
  - How do we store parameters?
    - Are we storing things on the tag, or using references to files on the Arduino/Host Machine?
  - Can we fit the commands onto one tag?
    - Multiple tags needed?
  - Does our standard work when we read the tag?
- Start testing C functions with preprogrammed NFC (continuous)
  - Is the Arduino accepting the NFC commands and executing them in the right places?
  - User experiences aren't required to be built at this point.
  - Testing shall continue to occur while modules are built

Week 6-7:
- **Core functionality needs to be done**
  - The Arduino should be to take a command from an NFC tag, and execute either on itself or on the Host Machine
  - C++ functions for media control, Bash scripting, and controlling digouts on Arduino must be working

- o   A few modules should be made for demonstrative purposes
- Materials for user experiences should have all arrived
- At least 4 user experiences by this point
- Majority of C++ functions will have been written and tested on Arduino and Host Machine (continuous)
- Model/print enclosures (5 days)

Week 8 - End:
- Build user experiences, curate content, and test stability. (until the end)
  - o   Write any remaining C++ functions
  - o   Make the experiences pretty and bug free
- Building the user experiences is probably going to take the longest, as it is going to have some QA involved to make sure they are actually enjoyable. Lots of talking to users.
- Write documentation for the C++ library (until the end)
- Prepare for demonstrations

AUDIENCE

CDEFO is being made for those who are interested in idea of computers having access to and being able to manifest our thoughts and emotions in ways that they hadn't considered before, all while the computers are completely abstracted from view. Basically those who are interested in the sentimental values we impose upon objects, and the ideas of home automation/PvC/"Internet of Things", but are perhaps too busy/not savvy enough to make their own platform. As a platform for research, this poses interesting questions about our attachment to objects. As a standalone project, it still offers a cool gimmicky way to run some home automation due to its modularity. I consider myself a part of both audiences, but I also understand that CDEFO will become quite expensive to implement. Therefore, I understand that it does exclude a fair number of people. It doesn't do much to improve quality of life, so it's mainly for people who have time and money to spend.

BUDGET

Item	Price
Adafruit PN532 NFC/RFID Controller Shield for Arduino	$40.00
10 NFC Tags	$20.00
Decent Soldering Iron	$50.00
Breadboard Jumper Wires + Breadboards	$30.00
Misc Components for Modules	>$100

OUTCOMES

As both a computer scientist and an electrical engineer, this project represents my ability to design both hardware and software solutions. After the demonstrations that I plan on holding, I hope that this project will live on in DCC through the C++ library (and the aforementioned documentation) and that people will be inspired pick it up and use it to personalize their rooms. I think its going to be a neat little software tool that can help bring a taste of pervasive computing to anyone wants to try. I intend on revisiting it as I learn more in my major and in my new job as a C++ developer. Maybe I can come back and design my own hardware interface that is open-source and easily hackable. Maybe I can use a different micro-controller than an Arduino that suits my needs specifically without any of the overhead of Arduino. Basically, the more I learn, the earlier in the design process I can go with this project. Right now, I will be using a lot of libraries that people have already written with hardware that people have already developed. I would like to go back and try to do as much from scratch as is realistic.

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