OFFICE PLANT #1

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Introduction

Walking into a typical, high tech office environment one is likely to see, among the snaking network wires, glowing monitors, and clicking keyboards, a plant. What a sad creature it is. Domesticated yet ill adapted to its artificial niche of human design, this generic plant sits on a desk corner under artificial illumination, serving as a placeholder for that which electronic machinery can not offer: personal attachment. Office plants are an expression of a need for undemanding presence in an efficiently impersonal environment. But there are better solutions:

Office Plant #1 (OP#1) is an exploration of a technological artifact, adapted to the office ecology, which fills the same social and emotional niche as an office plant. OP#1 monitors the ambient sound and light level, and, employing text classification techniques, also monitors its owner's email activity. Its robotic body, reminiscent of a plant in form, responds in slow, rhythmic movements to comment on the monitored activity. In addition, it makes its presence and present knowledge known through low, quiet, ambient sound. OP#1 is a new instantiation of our notion of *intimate technology*, that is, technologies which address human needs and desires as opposed to technologies which meet exclusively functional task specifications. OP#1 lives in a technological niche and interacts with users through their use of electronic mail. It acts as a companion and commentator on these activities.

Concepts

In this section we describe the major artistic and technical concepts that underlie the design of OP#1. These concepts are: Email Space, Text Classification, Plant Behavior Architecture, and Sculptural Presence. In our practice we simultaneously explore both spaces; artistic and technical constraints and opportunities mutually inform each other. The arrangement of this section exposes this simultaneous exploration.

Email space

Once, social interaction was defined by communal space. The properties of the space delimited the forms of exchange. The local pub, for example, was a space large enough to support a critical threshold of social energy, public enough that a cross-section of the local population was present, yet small enough that one could notice friends and acquaintances. This is the ideal of public intimacy; crowd presence without alienation.

Once, letter writing was bound to paper. In this medium, recording ideas required time and effort. This opened a space for contemplative introspection. Something could be learned about the self while writing to the other. This is the ideal of reflective intimacy; private sharing combined with distancing.

Technology, in its usual move of utopian plentitude, offers to satisfy both desires in one convenient package, email. While new forms of computer interaction are continuously created, email is the first computational forum for human social interaction to become ubiquitous.

The lack of public intimacy in the anonymity of the suburb is promised to no longer be a problem. Virtual communities can be formed and conveniently connected by email. With a lowered threshold for message creation and near instantaneous transmission, email is a conversational medium. But the conversants aren't subject to the constraints of real-time response. Given additional time to think, they can engage in the construction of letter writing. But this new medium, while pretending to offer the catch-free satisfaction of two desires, also introduces the watchword of computing into social interaction: efficiency.

Email encourages constant connection. Reflective letter writing may take place in the evening, after the work day is finished. But how inefficient to separate work and personal life. Email encourages continuous multi-tasking between work, play, and social interaction. Sitting constantly at the computer, words can be processed, numbers tabulated, games played, letters answered, all in one undifferentiated flow of activity. Where conversation and letter writing used to require distinct context shifts which involved changing mental state as well as physical location, the ease with which the user can switch contexts on the computer belies any distinction between these activities. And the ease with which an email can be sent ensures that all of us will be receiving dozens if not hundreds a day. With the blurring of historical distinctions surrounding concepts such as efficiency, pleasure, conversation and work, this increasing stream of information contains an odd mixture of work related announcements, junk mail, meeting requests, short quips from friends, and occasional heart-felt letters. Offering a seductive outlet for the primal human desire for social contact, email represents the transformation of the alluring familiarity of the letter and conversation by the logic of the machine.

As a new hybrid communication space, email is a fascinating site in which to observe human adaptation to and negotiation within a new medium. OP#1 is a commentator on this space. It physically responds to the social and emotional content of email messages received by the user. Unstructured, this email space is not accessible to scrutiny. In order to open this new social sphere for analysis and questioning we have developed, after reviewing a large body of email, the following categorization scheme.

Classifying email space

Figure 1 depicts the category tree employed by OP#1. An email message is either *private* (addressed to a single person) or *public* (multiple addresses). The tone can be either *formal* or *informal*. Private, informal email can be *intimate*, that is, email addressed to close friends. After passing through this initial category tree, every message can be assigned one or more of the categories in the box at the bottom of the figure. In this categorization scheme, every message is assigned a set of labels. For example, a message may be a public, informal announcement, or a private, informal, humorous request.

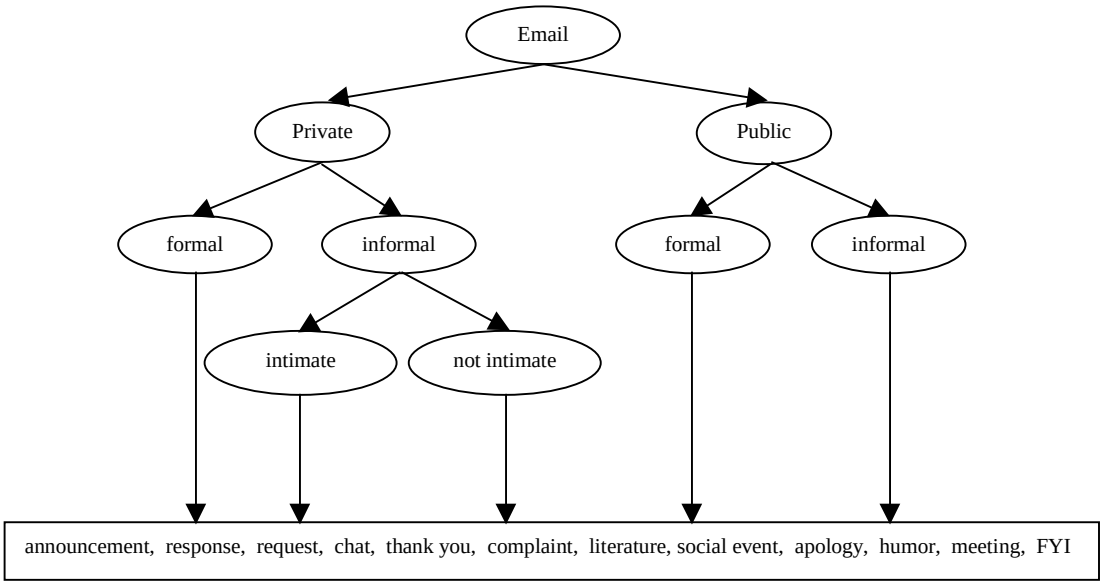

Figure 1

Text classification

In order to sort in-coming electronic messages into one of these categories we employ text classification. We use the practical, but efficient *Naive Bayes Classifier* [Mitchell97]. This method is a Bayesian approach for computing the probability that a new text belongs to a class given the words present in a text. This involves a learning step in which the various probability terms are estimated, based on the frequency of words occurring in the training data. These probabilities are used to classify each new instance by applying:

$$V_{nb} = \text{argmax } P(v_j) \Pi P(a_i \mid v_j)$$

where V_{nb} denotes the target value output by the classifier. $P(v_j)$ is the prior probability of a document class v_j. $P(a_i \mid v_j)$ is the conditional probability of a text belonging to class v_j given the occurrence of the word a_i.

In a Naive Bayes classifier, the number of distinct $p(a_i \mid v_j)$ terms that must be estimated from the training data is just the number of distinct attribute values times the number of distinct target values. This is a characteristic of the naive approach: all variables are conditionally independent.

Interestingly, the Bayes learning method requires no explicit search through the space of possible hypothesis. It is formed by counting the occurrences of various data combinations within the training sessions.

Plant behavior architecture

The state of the plant is dynamically modeled with a fuzzy cognitive map (FCM) [Kosko97]. In a FCM, nodes representing actions and variables (states of the world) are connected in a network structure reminiscent of a neural network. FCMs are fuzzy signed digraphs with feedback. Nodes stand for fuzzy sets or events that occur to some degree. At any point in time, the total state of the system is defined by the vector of node values. In our implementation, the nodes represent actions. The action associated with the action node with the highest value is executed at each point in time. The values of nodes change over time as each node exerts positive and negative influence on the nodes it is connected to. The FCM approach is attractive because it can resolve contradictory inputs and maintains sufficient state to exhibit incremental effects. Figure 2 shows the FCM for OP#1.

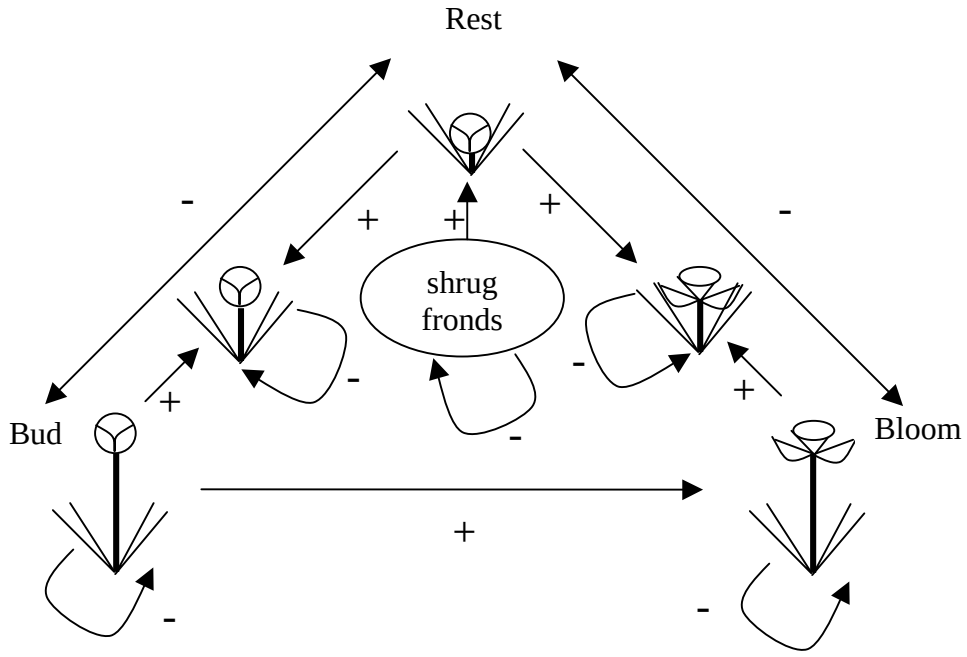

Figure 2

Sculptural Presence

Office Plant #1 is a desktop sculpture, an office machine that serves as a companion. In an environment of button pushing activity, OP#1, like a good piece of sculpture, is always on. OP#1 creates its own kind of variable presence in a user's email space, taking

on various attitudes and falling into decided silence. In its reactions it is a commentator on the events it analyzes. It goes beyond mirroring these events and delivers reactions as if it understood the significance of the exchange. But effectively, OP#1 is mostly inactive. It has a well defined sense of doing nothing, yet. It is simply there and in that sense a traditional piece of sculpture. Its physicality is as important as its text classifying capabilities.

OP#1's activity cycle is given by a defined period of 24 hours. During the active office hours it is receptive to user presence. After hours it uncouples itself from the daily trivia as it moves into a contemplative space for regeneration.

Physical design

OP#1 consists of a ball/bulb surrounded by metal fronds mounted on a base. The ball, a hammered aluminum sphere, can open and close. Mounted on a stem, it can also rise above the fronds and remain in any intermediate position. The fronds, made of piano wire, sway slowly, moving individually or in synchrony. Figure 3 shows a cross section of the office plant.

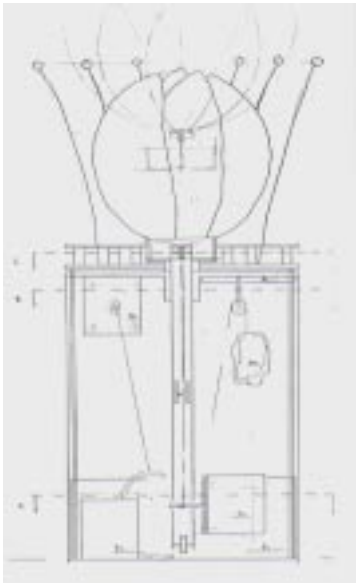

Figure 3

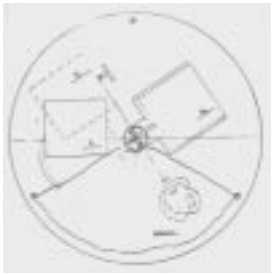

Figure 4, 5

Figures 4 and 5 show cuts through location A, B and C, respectively.

A window in the bottom of the base promises to reveal the inner workings of the plant. Rather than revealing gears, motors and electronics, this window opens onto the *datarium*, a scene composed of rocks, sand and a moving counterweight. As the stem raises and lowers, the counterweight moves into the *datarium* or out of view. A speaker housed in the bulb gives OP#1 its voice.

Figure 2 shows the Fuzzy Cognitive Map relating physical plant states. The three primary physical postures of the plant are *rest (protect)*, *bud* and *bloom*. In *rest*, the bulb is closed and fully lowered. The fronds occasionally move. In *bud*, the bulb is closed and fully

extended. In *bloom*, the bulb is open and fully extended. When the node associated with a posture has the most activation energy, the plant performs the action of moving to this posture from its current posture. *Shrug frond* is the action of tweaking one or more of the fronds. Activation energy from *shrug* flows towards *rest*. If the plant is shrugging too much, it moves into a protective posture. Activation energy from *bud* flows towards *bloom*; budding makes blooming more likely. *Rest* and *bud*, and *rest* and *bloom*, are mutually inhibitory. *Rest* and *bud* both spread their energy to an intermediate posture, and *rest* and *bloom* spread their energy to a second intermediate posture. The combination of the mutual inhibition plus the intermediate posture will cause these pairs of states to compromise towards the intermediate posture. Finally, the self-inhibitory links tend to cause values in the system to decay; in the absence of input, the plant will not stay in a posture for ever. When all of the nodes are zero, the plant will move towards the rest posture. As email is classified, energy is added to nodes, thus initiating the process of competition and cooperation between the nodes.

In addition to physical movement, OP#1 has a voice; it produces sound using the speaker in the bulb. These sounds provide the plant with a background presence. The possible sounds include variations on whistle, chant, sing, moan, complain, and drone. To simplify the diagram, the nodes corresponding to the actions to produce these sounds are not shown. The sound nodes all have mutually inhibitory links (only one sound will be active at a time). In addition, there may be excitatory and inhibitory links from body postures to sound nodes. For example, the bloom node may have excitatory links to the sounds whistle, chant and sing, and inhibitory links to the sounds moan, complain, and drone.

Implementing plant movement

Machines excel at performing fast and precise movement. For this task, the requirements are very slow movements. In order to achieve slow linear and rotary motion under space limitations we choose to use micro-stepping stepper motors. This allows both slow and precise movement control [Emerald96, Emerald97]. We have tested a variety of actuators for the fronds, amongst them Polyelectrolyte Ion Exchange Membrane Metal Composites (IEMMC) [Mojarrad97] and Shape Memory Alloy (SMA) [Dario97]. We choose SMA, as it requires little space, no climate control and provides acceptable reaction times (>1sec for 150um). Figure 4 shows a detail of the assembled SMA actuators.

Figure 6

Intimate technology

As stated above, OP#1 is an instantiation of intimate technology. As opposed to traditional machinery that is designed to perform well defined and economically useful tasks, intimate technology attempts to focus on human desires, in particular desires for contemplation and engaged leisure. Intimate technologies are best situated not in a sterile laboratory setting but in the home or office. Close to people, in bed rooms, kitchens, and as carry on items, intimate technologies act in the niches from which desires have been efficiently eradicated. In our conception of intimate technologies the device is a mediator between the realm of repeatable machine precision and human instinct. Intimate technologies are an attempt to reclaim the territories colonized by the unquestioned pursuit of efficiency. Intimate technology proposes to reintroduce contemplation into the design space and to build machinery that allows and fosters it. Intimate technology is a form of technology critique, but one that effectively uses what engineering disciplines best offer.

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