

MAS 961

# Ambient Intelligence

## **Final Project Report**

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## Introduction

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This project focuses on a remote awareness system using a wind chime as the output device. In keeping with the Ambient Intelligence vision of augmenting real life objects with digital behavior, I wanted to augment an object that is naturally designed to work in the background to carry a higher level of information. Often times, we find ourselves augmenting completely artificially purposed objects for use in the ambient channel. However, I believe that the limited peripheral bandwidth should benefit from natural mappings to the same extent as other input channels do. Another goal for the project was to keep the natural affordance of the wind chime, whether visual, aural, or functional, as similar to the unmodified version as possible. While it is possible to add lights or hammers to a chime, those modifications alter the basic semantics of the wind chime in a way that damages the natural mappings that we associate with the device, which we expect to be motivated in a pseudo-random fashion by the breeze. However, at the same time, I wanted to maximize the level of digital control over the object, in order to carry information as efficiently as possible. As such, I chose instead of tapping the chimes with hammers, to instead motivate the central striker of the chime itself in a way that allows the device to remain fully functional in its original way.

For an information mapping, the chime “displays” movement in a number of channels. The motion is captured by a camera and mapped to a channel. Each channel has its own chime. Of course, any number mappings are in fact possible by using sequences of taps. The cameras can be remotely located, and send information to the computer controlling the chime, which then handles the mapping. When a triggering event is detected, the striker is motivated to first hit the chime mapped to that channel in a pattern. The striker then moves at random to a gradual stop. While this is not a very direct mapping, it does allow for level of detail. When passers-by hear the chime, even if they know the purpose of the chime, they cannot discern the channel. However, over time, it becomes easier for them to map the chimes to locations, and a long time user can use the chimes to directly know when an area is “active.” Additionally, a number of other pattern mappings are possible. Each channel can also encode their identity (or other information) in the pattern of initial hits. For example, the number of taps may be mapped to the amount of motion detected, or the certainty with which the camera system believes it has seen the motion. It can also encode discrete information. One example would be to use a different initial pattern for a when a single person is detected, vs. when a mass of people is detected.

## Design

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Note: Please refer to the attached diagram for arrangements of parts. Since I wanted to use the striker normally and retain maximal control, a motor-based driver was out of the question. Therefore, I chose to use electromagnets to drive the striker arm. In early experimentation, I found that if the striker arm were flexible, the magnets simple moved the entire attraction ring (made of ferrous magnetically attractive rings attached in a stack to allow the magnets an area to act upon) and striker sideways and up, and then released it causing a large amount of vertical jitter, which in turn made the motion highly chaotic. I therefore replaced the part above the striker with a lightweight metallic rod that would resist the bending forces placed on it and keep the striker arm at the nominal vertical distance. However, since the striker arm must be able to move freely, I also designed a nylon omni-

directional joint at the top that prevented sideways motion, but allows full angular motion, thus allowing natural movement of the striker.

In doing the preliminary experiments, I also found that the striker itself had insufficient mass to move like a pendulum, even with the added mass of the now metallic striker arm. I found that the momentum retention mass at the end of the striker arm, far from being purely decorative, was in fact crucial to the pendulum-like motion of the striker. However, I did not want to replace the entire arm with metal because the added mass would make it difficult to move the striker, since additional metal will add mass to the long side of a lever arm from the point of view of the magnets. This led to some experimentation in attaching the nylon line from the mass to the metal rod. The end result was an arm that could be magnetically motivated to periodic pendulum-like motion, but at the same time was light and retained original angular motion flexibility.

The circuit design also posed a number of challenges, since the electromagnets require much higher voltages than the microcontroller, and at the moment of disconnection, produce a high voltage, high current inductive pulse, that despite protective circuitry can cause much damage. After destroying several chips in the search of a remedy, I was finally able to design a circuit that could handle the current requirements of the magnets (0.3 amps at 20 volts) while keeping safe the microcontroller. The microcontroller accepts commands from the computer via serial port, and can control up to 8 independent channels of magnets. It is the work of the computer to handle the timing of magnet activation and the pattern used, which makes the system highly extensible and customization, while retaining simplicity and robustness in the driver circuits.

In placing the magnets themselves, I also found that having the axis of the magnet well aligned with the chime center greatly improved the sound quality and ensuing random motion of the chime. Additionally, the magnets must be properly positioned to allow unrestricted motion (i.e., the attractor rings should not hit the magnet), while at the same time being close enough to allow the magnetic field to initially move the object. Since the magnetic field falls off as the square of the distance, it is important to have these adjustments correctly done. However, it also offers an option to soften the sound of the chime, which allows it to act more easily via background channels.

### Lessons Learned

In designing this chime, I took many of the lessons learned by Todd Machover's group in designing the Macy's Flower Show wind chimes and addressed many of what I consider flaws in that design. The chimes for the show were actuated by blowing on pinwheel, and did not have any directional control, being simply actuated by an offset motor that swung the striker to hit the chimes. Such a mapping greatly limits the amount of information the system (in fact, only one bit of information is really present). Additionally, the actuation method completely removed the natural auditory affordance of the chime and replaced it with a very ordered, sequential sound that only sounded like the sound in terms of audio output modality, not in the same semantic sense. I consider the semantic similarity provided by my design to be crucial to the use of the devices as peripheral audio interfaces, since it is that familiarity and expectation of ambient action that makes the wind chime a good candidate for augmentation in the first place.

I was also able to do a good bit of analysis and self-education in controlling solenoids and mixed-signal, mixed-voltage circuitry. Mixed voltage circuitry presents a number of challenges in designing and protecting circuitry, and this in itself forms an interesting venue of analysis. And finally, needless to say I found out a good deal about how a chime really works in the mechanical sense, and how the different tolerances, gaps, masses, and materials interact to form the sort of sound and motion we expect from a wind chime. This understanding, combined with some investigation into how people really perceive the chime, allowed me to get a much better idea of how the interaction should be designed and controlled.

## Conclusion and Future Plans

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In summary, I was able to create a network-controlled, motion sensitive wind chime that can be used for remote awareness systems using the peripheral channel. The design of the project focused on maintaining affordance, both physical and structural, and thus presents some interesting channels in term of designing the augmentation and implementing it.

In the near future, I would like to clean up the API to the camera, and allow easy use of network-attached cameras and online video clips/web cam shots. I would also like to clean up the circuit design and set up magnets for all the remaining chimes. The magnets are currently attached with adhesive tape, and thus require design of a mounting system that can accommodate changes to the distance the magnet is from the attraction rings. However, this must be delayed until a suitable magnet to control the motion is found, since the ones currently in use are too large for the space available. Lastly, I have a number of possible uses for the generic notification device, and would like to quickly investigate them in order to understand the sorts of data that could benefit from an interface like this.