Date: 12/05/13

To: Dr. Nazmul Ula

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Subject: Crow Deterrent Final Report

I. Situation

The objective of this experiment is to design and implement an electronic system that can discourage crows from eating the eggs of the California Least Tern, an endangered species that lay their eggs near shores of Venice beach.

It is of importance to the LMU Biology department to protect the tern species. Urban build up and human incursion in the Venice area has significantly reduced the tern's natural habit, limiting the areas in which they can lay their eggs. Although, there is a reserved area where the terns can lay their eggs, it is disadvantageous for the terns, because one of its main predator, the American Crow, can easily predict where the terns will lay their eggs.

Ideally, when a predator outnumbers the prey, it is desirable to eliminate the predator, in other words, killing the crows that pose a threat to the terns. However, due to the territorial nature of crows, if a family is exterminated, two families would move into the left territory.

The best explored option is to change the local crows' behavior by taking advantage of how smart they are, by associating a negative experience every time they peck a tern's egg. Also, because crows have a lifespan of about 30 years, "educating" the local crows poses as a great investment.

II. Suggested Actions From Biology Dept

Initially quail eggs (approximately the same size and shape as a California Least Tern egg) were drained and filled with an emetic fluid. Theoretically, when the crows attempted to eat these eggs, they would have an adverse reaction and associate the negative side effects with eating the eggs. Given the high cost of the emetic fluid and limited number of decoy eggs, this approach was a temporary solution that only affected a small portion of the near-by crow population. The Biology department is currently looking for a more cost-effective, permanent solution that is recurring and capable of deterring for extended periods of time.

The first solution explored and requested by the Biology department was to create a system that will electrically shock the crow, as a response for pecking the egg. This solution was explored to certain extent, however several electrical and biological factors make this approach inefficient. First, the location of the bird cannot be predicted when it is attacking an egg so the system would have to be a complete circuit regardless of where the crow is standing around the nest. Second, the overall resistance of the bird and conductivity of its beak and feet are very high and which would require a significant amount of voltage for the crow to feel a shock. Lastly, this approach would not discriminate between a crow and a tern, and would shock any object or animal that completed the open circuit. For these reasons, more solutions were explored.

III. Proposed Solutions

The solution to deterring the crows from attacking the tern's nest can be broken up into two parts. The first part is how the crow will be detected from attacking a nest, and the second part is, once the crow is detected, how will it be deterred from the nest.

One way the crow can be detected is by weight. The terns weigh between 39g and 52g[1] and the crows weigh between 316g and 620g[2]. This means that there is a significant enough difference between the weights of the birds so that a crow can be distinguished from the tern even if the tern lands hard or there are multiple terns in the same spot. This could be implemented using a pressure sensor plate under and around the nest that would be calibrated to ignore the weight of the nest itself. However, this system could have problems with detecting the crow's weight depending on where on the sensor plate the crow is. Furthermore, because the nests are in the sand on the beach, wind could blow sand onto the sensor plate and set the system off prematurely.

Another way to detect the crow is to use image processing to distinguish between the black crows and the white terns. The crows do feed during the day so it would be known that there would be adequate light on the birds. However, this solution would be expensive, and possibly not completely accurate with non uniform background colors and other animals.

A third way the crow could be detected is by detecting when the crow pecks the egg. This can be done by placing a vibration sensor inside a fake egg that would trigger when the egg is touched. Because this method would be invasive to the tern's nest and since terns are endangered so their nests cannot be altered, it would have to be implemented in decoy nests in an attempt to train the crows to learn that attacking nests are dangerous in hopes they would have the same reaction to the real nests. This was determined to be the best system to detect the crows.

One way the crow can be deterred is by an electric shock. This could be implemented using a charged capacitor that discharges quickly enough through the crow to create a shock. One problem with this is that the crow has a large resistance through its beak which would make it difficult to discharge through it quickly enough to create a shock, especially if the crow only pecks at the egg for a small increment of time.

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[1] "Least Tern." *Wikipedia*. Wikimedia Foundation, 20 Oct. 2013. Web. <http://en.wikipedia.org/wiki/Least_Tern>.

[2] "American Crow." *Wikipedia*. Wikimedia Foundation, 24 Oct. 2013. Web. <http://en.wikipedia.org/wiki/American_Crow>.

Another way to deter the crow would be to startle it with a bright flash and/or a noise. According to customer, Dr. Strauss, crows have been shown to be very sensitive to intense light. Furthermore, there are many crow and bird deterrent products that exist on the market today that use audio sounds and bird distress calls to deter birds[3]. This was the deterrent system that was chosen to be implemented.

IV. Field Visit

On Thursday, 07 Nov, the tern preservation site was visited. The preservation site is located in Venice, CA on the beach. Although the terns were not at the location during the time of visit, visiting the site has lead to several observations which have influenced the system design.

Figure 1: Venice Beach Preservation Area, with two crows in the background

The first observation was the method by which terns create their nests. These nests are essentially shallow holes dug in the sand approximately 6" deep with an opening 12" in diameter. The simplicity of the nests will make it easy for decoy nests with deterrent systems to be constructed within the preservation area. Although the initial prototype is focused on proof of concept rather than field implementation, once a field-ready system is built, the plan is to bury the circuitry and power supply of the system in a weather-proof box with the egg sensor and strobe/audio device outside of the box, connected to the circuitry via insulated wires. A layer of sand will be placed over the box, and the egg sensor (along with other quail eggs) will be placed on top of the sand layer. A decoy nest will then be built up around these eggs. The strobe and audio device will be placed outside of the decoy nest. The plan is to teach the crows to realize that nests with a speaker and strobe next to them result in an unpleasant response. Inactive speakers and strobes can then be placed next to actual tern nests once they return in hopes that the crows will assume these actual tern nests will result in unpleasant responses as well.

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[3] Beason, Robert C. "What Can Birds Hear?" *USDA Wildlife Research Center* (2004): n. pag. *Digital Commons*. 1 Sept. 2004. Web. <http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1076&context=icwdm_usdanwrc>.

The second observation was the specific location within the preservation which the terns build their nests. The preservation area is approximately the size of a football field and runs parallel to the shore. However, the terns only use the the western-most quarter of the preserve (closest to the shore) for their nests. In order for the system to be implemented effectively, the decoy nests must also be located within this quarter of the preserve. Otherwise, the crows may not associate the decoy nests with the actual nests of the terns.

The final observation made during the field visit was the effectiveness of the crow distress call. There were several crows within the preserve area during the visit. One of the crows wandered close enough to the fence to hear a the crow distress call played from a cell-phone speaker. The crow immediately flew away and within a few minutes of the call being played, no crows could be seen within the area. Since there were not any more crows within the area to attempt to reproduce the initial results, the distress call effectiveness cannot be definitively realized. However, the distress call seems to be a promising deterrent. The effectiveness of a strobe (especially in daylight) was unable to be tested, but will still be included in the system design in hopes that it will increase the effectiveness of the distress call deterrent.

V. Design Considerations

Initially, the proposed input for the system was a PIR motion sensor. However, these sensors are extremely sensitive and it is recommended not to place the sensor in direct sunlight (which it would have been if implemented). Due to the unreliability of the device, a different system input was designed, built, and tested. Instead of detecting motion using IR waves, the presence of a crow will be detected using a vibration sensor within a decoy egg. When the egg is pecked or moved, the presence of the crow will be detected. This input method was built using a sensitive spring with center rod. When the spring and rod are not touching, the input to the system is tied high. However, when the spring vibrates and touches the center rod, input is shorted, pulling the input low. A more detailed explanation of the circuit is described in the next section. Figure 2 illustrates the conceptual design tested in the lab (left) and the “field ready” sensor in the inside of a decoy egg (right).

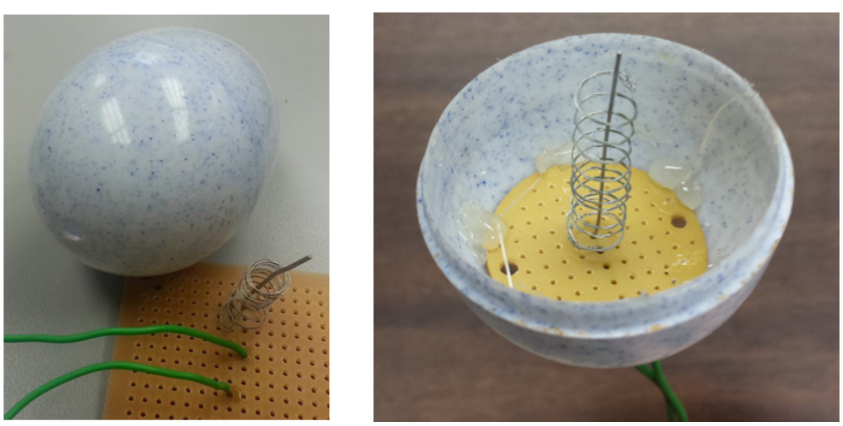

Figure 2: Spring Vibration Sensor

Additionally, the use of a microcontroller capable of reading a memory card containing the crow call was considered for use. Due to cost and lack of simplicity, an alternative method was used. A digital re-recordable module, similar to those used in musical greeting cards, was used. The module is capable of recording up to 20 seconds of sound which is plenty for the purpose of this system. The module was modified and implemented in the system. The device came standard with a push button to play the output. This button was removed and and connecting wires were soldered to both ends of the button circuitry. An analog switch, using a transistor was connected to the wires. The modification was tested and successfully output the distress call when the vibration sensor was tripped.

The test circuit schematic is shown in Figure 1. An explanation of the overall system functionality follows.

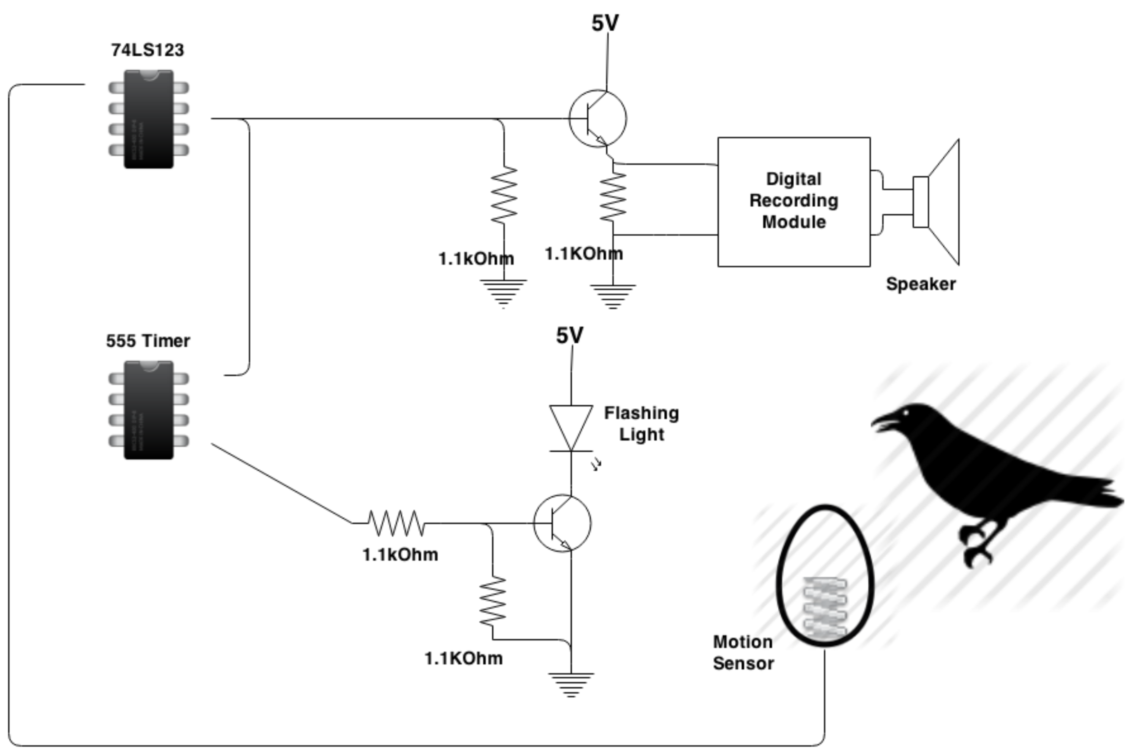

Figure 3: Design schematic Circuit Crow Deterrent Project

VI. System Functionality

In the Design Schematic circuit in Figure 3, when the vibration sensor inside the egg is is activated by the crow pecking the egg, the circuit is completed every time the spring inside the vibration device touches the active high pin, sending a fluctuating signal to the 74LS123. The 74LS123 is set to sense the signal change from the vibration sensor, once the signal change is detected then a 20 second active high signal is sent to the 555 timer and to the trigger of the Digital Recording Module (DRM).

Once the 555 timer is triggered, it drives a LED light with a 5000mcd; the output signal of the 555 timer is a 60% duty cycle square signal with a frequency of 2 Hz, which is the flashing frequency of the LED. It was chosen arbitrarily with the intention to cause discomfort to the crow. This frequency can be adjusted after determining which frequency works best to deter the crows.

The DRM is also triggered by the 74LS123 device, once activated it will play a pre-recorded crow deterrent distress call[4]. Figure 4 shows the DRM device and its components. In order to record the deterrent distress call, the DRM was placed 2-3 inches away from the speaker outputting the distress call while pressing the recording button. To play the distress call the play button should be pressed, however this button was replaced with a switch (NPN transistor) controlled by the 74LS123 device.

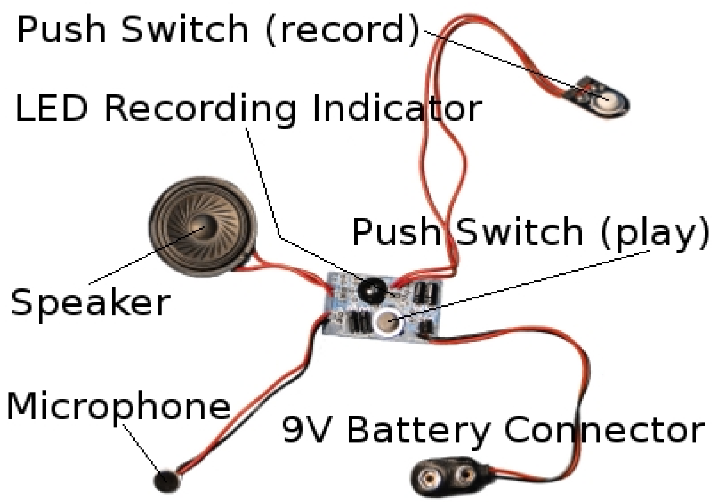

Figure 4: RadioShack 20 second Digital Recording Module (DRM)

The DRM has a great playback sound quality as long as the recording was done according the instructions and the desired recordable sound has high quality, and therefore will be recognizable by the crow and will hopefully produce the desired effect of the deterring it.

Because the design uses transistor switches to trigger the LED and speaker, the circuit is easily modular. If the speaker or the LED need to be changed to experiment with different deterrent devices, they can be swapped with the current devices and can use an new power source without having to redesign the device. Figure 5 illustrates the completed test circuit.

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[4] UC Davis Crow Control, Paul Gorenzel
http://crowcontrol.engineering.ucdavis.edu/DOCUMENT.HTM

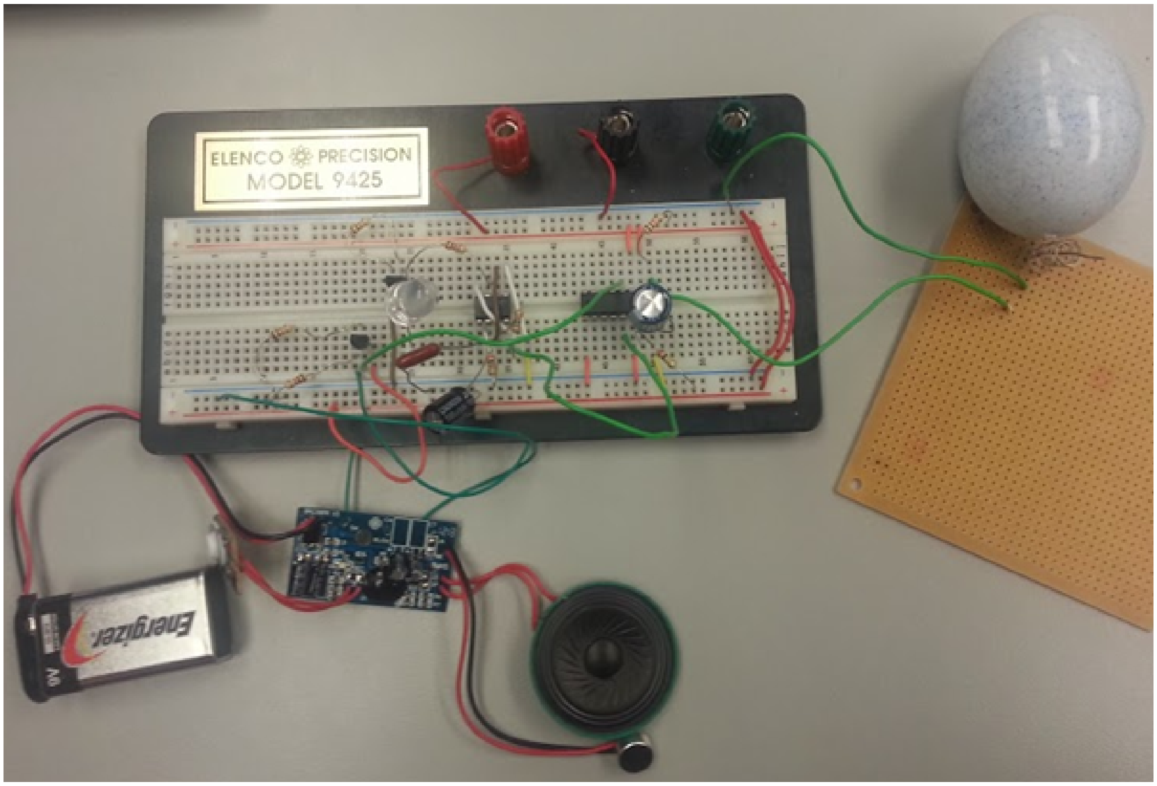


Figure 5: Completed Test Circuit

V. Final Design

After the circuit in Figure 5 was built and tested in the lab using components and power supplies found in the lab, the system was rebuilt on a soldering board and inputs were modified to allow the circuit to be powered with a rechargeable 6V battery pack and two 9V batteries. This allowed the system to become a mobile, compact unit capable of being tested outside on actual crows. During this modification process, two additional changes were made to the design tested in the lab. The 200Kohm resistor responsible for determining the length of the output pulse of the 123 timer was replaced by a 1Mohm potentiometer. This allows the length of the distress call and strobe to be adjusted as seen fit by the user. Also, the 1.1Kohm resistor responsible for the frequency of the 555 timer output was replaced by a 1Kohm potentiometer. The strobe rate of the LED was determined to be too slow with the fixed 1.1Kohm resistor and replacing it with the potentiometer allows for the strobe rate to be adjusted by the user. Both of these additions allow for the system to be more dynamic, capable of a variable output consisting of variable strobe rates and variable output durations.

The second change made to the system was the replacement of the digital recording module speaker with a more powerful 8ohm speaker. In order to power this speaker, a TDA7052 1W amplifier with volume control was added between the recording module output and the new speaker. This allowed for a much louder distress call that can be turned up or down to meet the needs of the specific scenario.

A picture of the final, “field test ready” circuit is illustrated in Figure 6**.** A schematic of the circuit design and component values used can be found in Attachment A.

Figure 6: Final “Field Ready” Deterrent System

VI. System Performance

The system is powered by a 1600mAh 6V rechargeable battery. When the system is idle, it draws a 25mA current. The system can theoretically remain actively idle for 64 hours. When the system is active, it draws 43mA (powering the LED strobe) from the 6V rechargeable battery. The system can theoretically last 37.2 hours in the active state. In both the ide and active state, the speaker amplifier, which is powered separately by a 9V 550mAh battery, draws 6mA. Theoretically the speaker amplifier can remain powered for 91.6 hours. The recording module is also powered by its own 9V 550mAh battery. The recording module does not draw power when idle and only draws 3mA when active. Theoretically the battery life of the recording module is 200 hours. Out of the three scenarios, the 6V rechargeable battery will run out before either of the 9V battery. Therefore the battery life of the system is 64 hours to 37.2 hours. Assuming the deterrent system is only active once or twice a day (20 second durations), the drain on the batteries from being active is negligible and the operational battery life is very close to the projected 64 hours.

VII. Test Procedure/Results

The crow deterrent system, shown in Figure 6, was successfully tested several times in laboratory condition. The system is triggered every time the egg is senses vibration (peck by a crow), responding with a flashing light and a distress call. Ideally a test at Venice Beach was desired. However, due to time constraints and lack of a monitoring devices, testing at this location was not possible. Instead, the crow deterrent system was tested at four different times at the Loyola Marymount University (LMU) campus.

The first three tests were at Location 1, illustrated in Figure 7, in front of the Doolan Building. During the first set up at Location 1, cheetos were used to lure the crows close to the system. The egg sensor was placed inside of the chip bag with the idea that the crows would set off the system when going for the food. Although pedestrian traffic was heavy, crows showed up at the site. Unfortunately the crows were able to take cheetos out of the bag without triggering the deterrent systems. This was attributed to the elongated shape of the cheetos being too easily accessible sticking out of the bag. For this reason, the second time the system was tested, Doritos were used as bait because of their flat shape and the ability to place the egg sensor on top of the chip. But crows did not showed up at this location, presumably because of the weather conditions (rainy and cold) and the pedestrian traffic, forcing the selection of another location.

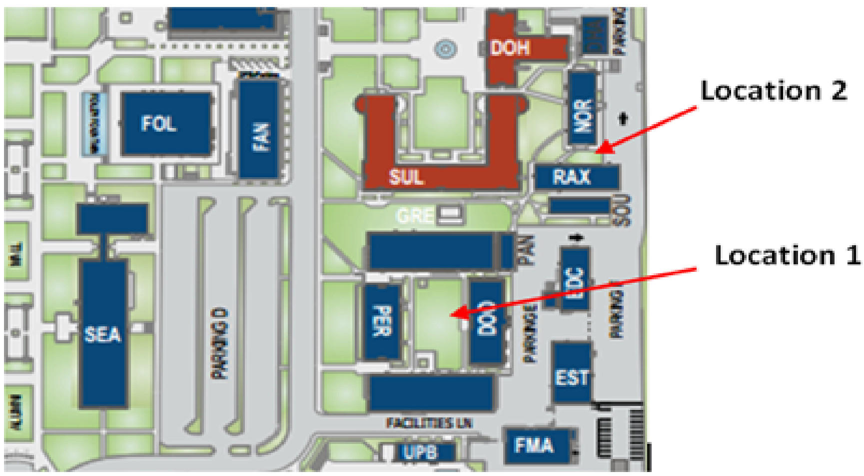


Figure 7: Testing locations at LMU

A member of the team identified Location 2, Figure 7, between North Hall and Research Annex buildings where numerous crows were witnessed gathering several times. This time, the team acquired a game camera to record the events allowing the site to be able to be monitored without humans present to scare away crows. This greatly increases the chances of crows approaching the site confidently. At this site the system was laid out at 1000 hrs. The crows triggered the system after about an hour of being set at Location 2. Figure 8 shows a group of crows triggering the system and leaving the site almost immediately after the distress call starts playing. The team reset the bait but the crows did not come back to this site for the rest of the day until the system was removed at 1900 hrs. This points to the conclusion that the system was successful in teaching the crows not to attack. However, this conclusion would have to be backed up with more testing and data.

Figure 8: Picture Storyboard of Crows being Deterred[5]

VIII. Conclusion

The advantages of using this system to deter crows are that it does not required to be reset after the sensor is triggered and its ability to operate autonomously once set up. Also, it was estimated that this system will operate with two 9V batteries and one 6V battery pack for a idle period of time of 64 hours. Ideally, this system will have to be monitored every 2.6 days for battery replacement and maintenance.

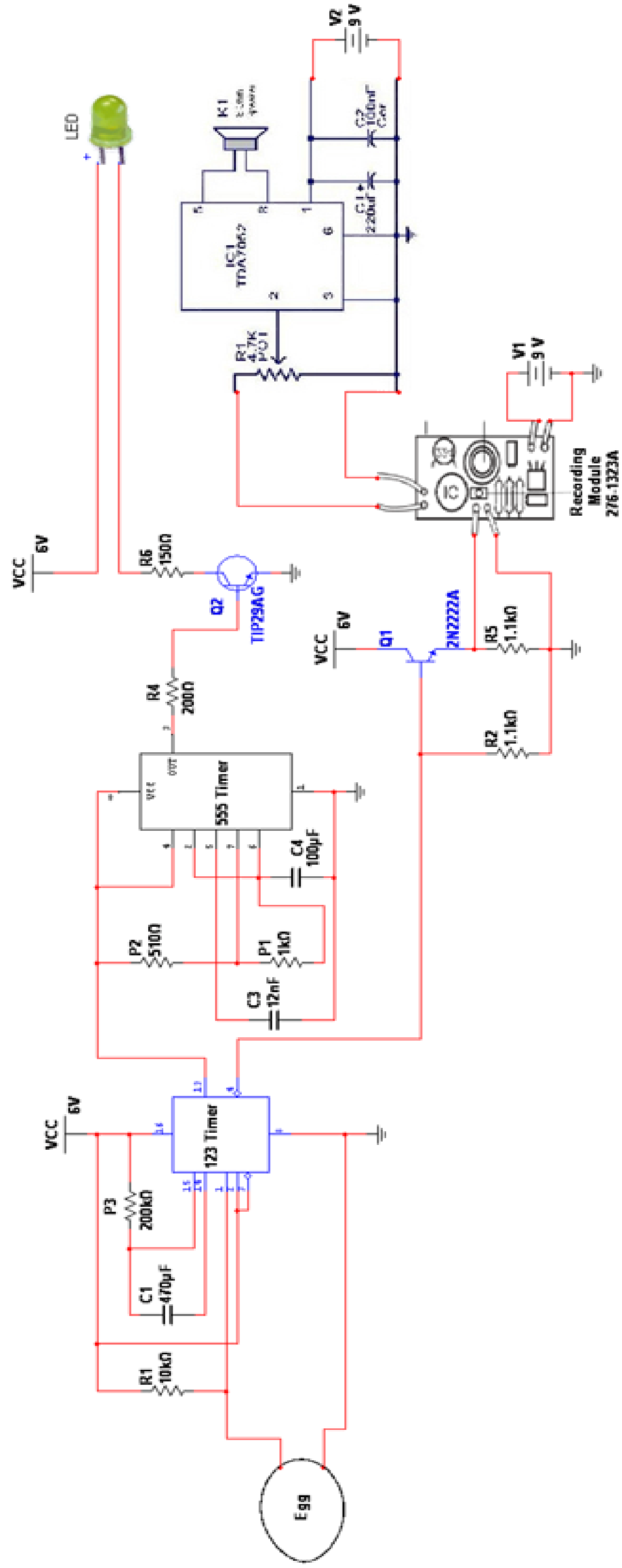
The successful testing results are encouraging. The footage captured by the game camera was shown to Dr. Strauss, customer and Executive Director of the Urban Ecology Department at LMU. He was pleased with the results to this point. However, due to the limited amount of time the game camera was available for use, the team was unable to replicate and record these results at different locations. Therefore, more field tests will be required in order to determine whether or not the system is an efficient crow deterrent system and valid solution to the situation at Venice Beach.

[5] Full Video at: http://www.youtube.com/watch?v=fsnAfnVG9WU&feature=youtu.be

In order to used this system at the site, it will have to be sealed and weather proofed and a more realistic egg sensor would have to be made. Also, more LED lights can be added to the strobe output to increase the visual deterrent effect. Similarly, a more powerful speaker can be added in order to increase the sound deterrent effect.

Attachments:
A: Final “Field Ready” Circuit Schematic
B: Supplemental Photos

Attachment A:



Attachment B:

Figure 9: Location 1 Crow Deterrent System

Figure 10: Location 2 Crow Deterrent System

Figure 11: Speaker and LED Strobe Light Outputs

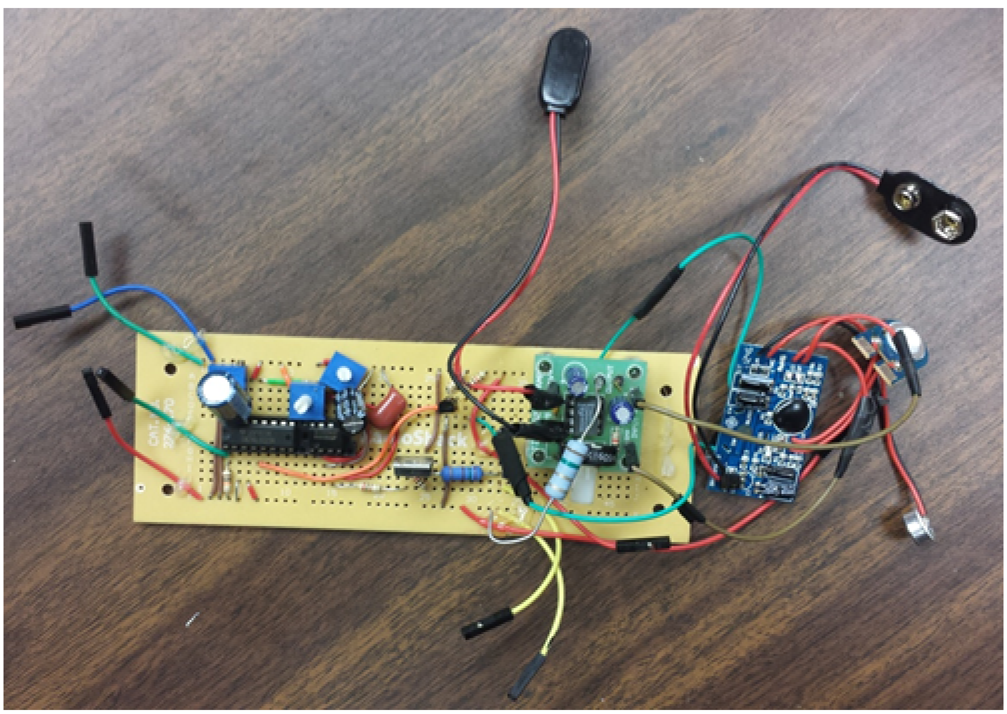


Figure 12: Circuitry on Solder Board