Morph Chair
- Project #1 Report

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Why Morph Chair?
We got the idea of morph chair because of the notions of Ubiquitous Computing - a model of computing in which computer functions are integrated into everyday life, often in an invisible way (http://en.wikipedia.org/wiki/Ubiquitous_computing). As a type of furniture, we could trace the history of folding chair back to Egyptian time (“The Illustrated History of Folding Chairs”, http://www.designboom.com/eng/education/foldingchair.html). And as a daily object, chairs are something that everyone is familiar with. But they are always static! We thought it would be great fun if we design an interactive chair so that it would bring us a little surprise.

The Initial Plan (Figure 1)
Morph chair can gradually change its form. At the beginning, the chair is folded at the floor. When someone stands on the carpet in front of the chair space (Figure 1-1), the chair will be triggered and first rotates its back up and forms a floor seat (Figure 1-2). Then the legs of the chair raise the chair to present us a side-x chair (Figure 1-3). As illustrated by the figure 1-4, finally we want to build a rocking chair with some rocking mechanism underneath. The rocking motion can be controlled by a variety of sensors to achieve some entertaining effects.

The Unsuccessful Model vs. the Working Morph Chair
We have two physical chair models: #1 – unsuccessful model and #2 – working model. The Chair #1 can only achieve the first step – rotate the chair back up. The chair #2 can further...
stand up and then performs the “sit-down” and fold again smoothly. Table 1 shows the differences between the two chair models.

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Table 1: Comparison between Chair #1 and Chair #2

(1) Chair #1 – the unsuccessful model (Figure 2)

The first lesson of chair #1 is that we spent (or wasted?) too much time on the 3D printers: it took 7-8 hours to print out our pieces in average and we had to wait for another night after putting all pieces in the bath. Often only when we played with physical components can we discover some problems. So it took us one day or so to make every improvement on the 3D model.

We found the chair design has some characteristics:

a. It is nearly impossible to divide the chair design into modules: the chair is a highly integrated design, which means that all parts or factors are actually closely related.

b. It is like a single threaded design process, which means we have to proceed to the next step until we make sure some function or a feature can be achieved.

c. It is hard to discern a problem without assembling all the parts.

Accordingly, above features brought us some difficulties:

a. The design process is iterative: we have to make changes back on previous parts if we found a problem later on somewhere.

b. It is hard to organize our team work.

We should admit that both of us are not familiar with Mechanical components. This caused both design and manufacture complexity. We used the combination of straight bevel gears (Figure 3) and rack and pinion gears (Figure 4), which intended to pull the four legs of the chair and force it to stand up. We designed 4 sets of rack and pinion gears, each of which is to pull one leg. A
Bevel gear is composed of a horizontal gear and a vertical gear. We used a motor to drive a horizontal gear and allocated two vertical gears on its both sides in symmetry. The first problem we identified was that the two vertical gears rotate in different directions! We tried to solve the problem by using the pair of vertical gears for one front leg and one rear leg respectively in order to pull them in opposite directions. This solution led to the complexity of 3D modeling because of asymmetry.

Because we thought microcontroller provides with the possibility to build more complex and flexible system, we use Arduino board with Atmega8 chips. Compare to PicoBlocks we used later, microcontroller requires low level programming and it is harder to have them work stably. It means more work too since we need to wire the breadboard after programming.

(2) Chair #2 – the working model (Figure 5)

This time, we switch to laser cutter, which is much faster so that we could test different parts in “real time”. Another benefit is that we could use lighter wood panels since we noticed more gravity means more motor power, which could be a critical problem for Lego motors.

One important improvement of chair #2 is that we simplified the mechanical design by removing the bevel gears (we found previous mechanism of using bevel gears to change rotation direction was totally extra.) and using only 2 sets of rack and pinion gears, each of which is either for both front legs or for both rear legs. Since either front legs or back legs have the same motion, we could simply bind them together and apply one set of rack and
pinion gear to each pair. (Figure 6)

We should say “thanks” to John, who gave us great advice of “gear box”, which helped us out with the issue of motor powers. We use 2 sets of gear box to increase the force of both motors, which drag chair legs forwards and backwards. At the same, it slows down the rotation speed so that the chair could “stand up” and “sit down” with an ideal performance.

Another hard problem is about how to conquer the unbalance. For the purpose of rotating the back up (Figure 1), we put a small Lego motor at the back of the chair and it caused serious unbalance problem – when the chair stands up, it will fall back. Our solution is to embed and glue a number of screws and nuts at the front to balance the chair.

Finally, use of PicoBlock and Lego toy pieces apparently contributed the final version too. The former makes the programming process fairly easy and the circuit robust, while the latter makes sure that all components connect and work harmoniously.

**Conclusion**

If we consider the whole design process as a learning process, it is hard to say that chair #1 is an unsuccessful story. Since we had thought over spatial relationships thoroughly and got the 3D models at this phase, it was not hard to convert them to the version suitable for the laser cutter. Moreover, we found out problematic elements and discussed them in depth. All these contributed to the chair #2, which we finished in 2 days. We learn from both failure and success stories.