Fall Research Proposal: MEMS actuators

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I. Big picture

- What is the overall problem that this and related research is trying to solve?

The research is trying to use MEMS actuators to generate macro scale movement.

- Why should people care about the problem?

MEMS actuators have very small dimensions – on the scale of cubic millimeters. If macro scale movement can be generated by these actuators, it is then possible to dramatically reduce the size of robots and implement exciting things like paper robots powered by these MEMS actuators.

- What is the general approach to solving this problem?

First, because the MEMS system is linearly actuated and cannot handle out of plane forces, a linkage needs to be established for the MEMS system to implement motions such as revolving and folding. Second, the properties of the folded materials need to be studied and characterized, the most important being the torque needed to fold these materials. Finally appropriate linkages are selected and implemented based on the folding characteristics of the materials.

- How will this approach result in a solution?

A macro-scale system actuated by MEMS actuators, with help of linkages

- What is the value of this approach beyond this specific solution?

Eliminate the need for large actuators in certain robotic systems such as paper robots; reduce size as well

II. Specific project scope

- What subset of the overall problem are you addressing in particular?

For this quarter, the focus will be on the folding characteristics of different materials, namely the torque needed to transform the material from one angle to another.

- How does solving this subproblem lead towards solving the big picture problem?

Help choosing appropriate material and linkage based on the restrictions of MEMS actuator

- What is your specific approach to solving this subproblem?

Conduct automatic force experiments on different kinds of paper, with varying characteristics such as paper type, perforation and width

- How will we know that this subproblem has been satisfactorily solved?

Establish a force/torque database recording the folding characteristics

- What is the value of your solution beyond solely solving this subproblem?

Help constructing the linkages for MEMS actuating by determining appropriate material configurations

III. Background/Related Work/Reference

Nathan Pilbrough of LEMUR has been working on this project since Winter 2017 and has made substantial progress regarding the whole project, especially linkages. After research, Peaucellier-Lipkin linkage was theoretically verified to be compatible with MEMS actuators but failed after practical implementation because the paper was not rigid enough; as a result, simpler linkages such as Hoeken linkage are needed.

Force experiments for paper folds were also conducted in June 2017 and we obtained data points in the paper folding process. However, the experiment was conducted using digital scale and we manually recorded data, which was inefficient and inaccurate. During the summer, I designed an automatic force measuring system using load cell. After the system is assembled and configured, it should substantially increase the efficiency of force measuring.

IV. Goals, deliverables, tasks

Goals for this quarter: finish the force experiments, measure folding characteristics for different types of paper; (hopefully) implement the appropriate type of linkage based on the data obtained

Specific milestones:

- Finish assembling and testing the automatic force measuring system by the end of October;
- Finish writing force experiment pre-lab setting the correct mounting system for the experiment and combining the load cell system with stepper motor and paper fold by early November;
- Finish paper fold experiment by the end of this quarter;
- Work on linkage implementation if there's spare time

Deliverables:

- A functional, accurate automatic force measuring system
- A series of data points and curves on paper folding detailing the effect of age, hysteresis, relaxation as well as different configurations, including paper type, perforation, width and more