Subject: Bistable auxetic
Posted by 32Q2 on Fri, 20 Jan 2012 01:44:00 GMT
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Hi all,

I've been interested in creating materials with unusual mechanical properties for a while - see this video for some of my older experiments with the sort of thing I'm talking about.

Now I'm looking to develop some of these ideas further through 3d printing and making use of the elastic properties of WSF (inspired also by these 'digi-fabrics')

I'm attempting to create a material which will be both auxetic (having negative Poisson's ratio - so it expands perpendicularly as you stretch it instead of contracting like most materials) and bistable (having two different unstressed states it can snap between, separated by an 'energy hill').
As far as I know this would be the first material to have both these properties.

Here is how my mechanism should (hopefully) work:

(The squares are attached to each other by axles at their corners and to the green spring system by axles through their centres. See how there are 2 different configurations of the squares for which the springs are relaxed)

and here's what I'm actually planning to print:

(dimensions in mm)

Do you think the clearances will be sufficient for the axles to work and not fuse together ?
I've stuck to the 0.6mm guideline, but I'm not sure if this still applies when the gaps go around corners like this.

Also - do you think the springs will be able to bend sufficiently to allow the proposed motion ?
I've printed struts on other models at 0.8mm and they are fairly flexible, though much longer than these.

I want to keep the individual units as small as possible, because I think the interesting behaviour will come from having sheets of many units. (I'm hoping it will be possible to snap different parts of the same sheet into the different stable states, and move the wave between them around).

The clearances can't be too big, otherwise the springs will not be stressed in the in-between state.

This will be printed already assembled, but an alternative option might be to print the expanded squares, and the spring network separately, then snap them together. This could maybe allow tighter fits, but snap-fits would pose their own challenges.

Anyway, I'd be interested in any of your thoughts or ideas on this design and how it might be improved.
Thanks!

Subject: Re: Bistable auxetic
Posted by JamesSaunders on Fri, 20 Jan 2012 18:51:47 GMT
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This is awesome, and I hope it works. I don't have experience with printed moving parts yet, but I'd think you could print a test sheet for cheap enough. I'd suggest removing material from the "squares" to reduce costs.

Subject: Re: Bistable auxetic
Posted by Magic on Sat, 21 Jan 2012 11:47:20 GMT
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Wow, that's an excellent idea! I hope it will work: please keep us updated.

0.60 mm should be enough, go to 0.75 mm if you don't want to take risks. I am more concerned with the 0.80 wire. I would try at least 1.0. Less that 1mm is quite fragile in my experience.
The section look like an ellipse not a circle: I am afraid that if it is the case, the wire will bend in the direction of the smallest radius, which is probably not what you want.

Have a look at this video: the wires are 2mm and it is bistable
Good luck.
Oh one last thing: your model should be a good candidate for this new material...

Subject: Re: Bistable auxetic
Posted by 32Q2 on Sat, 21 Jan 2012 12:53:01 GMT
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Thanks for the feedback and advice guys.

I think I'll scale the whole thing up by 25% then to be safe (and maybe print just 4 squares at a range of scales too, to see what works best)

The springs are actually circular, it's just the angle that section is cut at.

Nice bracelet, and thanks for pointing out that new material update. It does indeed look like it could have a lot of interesting potential for this sort of thing.

Will post an update when it arrives...

Subject: Re: Bistable auxetic
Posted by electrobloom on Sat, 21 Jan 2012 15:16:25 GMT
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Hi,
This looks brilliant, cutting edge stuff! Really keen to see how it turns out so upload a video once you've received your sample.

I have also started to produce some moving parts and the only issue I'm battling with at the moment is to ensure there's enough space for the unused powder to be removed. I've started to include holes in surfaces to make this easier.

Keep us informed of future developments.

Mark.

Subject: Re: Bistable auxetic
Posted by henryseg on Sat, 21 Jan 2012 15:53:50 GMT
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This looks very cool. It's interesting that all of the experiments in the video involve 3-dimensional movement, with origami folding to get the properties you want. This one would really have all of the action happening in the plane (well, parallel planes).

Subject: Re: Bistable auxetic
Posted by TurtlesAreCool on Sat, 21 Jan 2012 16:59:41 GMT
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Very interesting - I'd love to see how this turns out. I must second the concern about the .8mm thickness. I constantly find that things are not as big as I thought they are, once I get the print.

Subject: Re: Bistable auxetic
Posted by Magic on Sat, 21 Jan 2012 17:28:19 GMT
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There is something I cannot understand:
- when looking at your animation, for half of the time the green dots (axis) seems to be stuck to the blue squares (they rotate exaclty in the same way). But for the second half of the animation, there are rotating in opposite directions.
Are you sure the green structure should not go from one pattern to squares pattern to a different pattern where the orientation of the rounded tiles are inverted (horizontal instead of vertical and vice-versa) compared to the first one?
I can understand that you need hinges for the blue squares, but I thought the green dots should be welded to the blue squares (if that makes sense).

[EDIT] for example I thought the first horizontal green segment would bend once upward, once downward alternatively. The amplitude of the angle would be 90Â° which is precisely the value of the rotation of the blue square and thus the extremity of the green segment could be welded to the blue square.

Subject: Re: Bistable auxetic
Posted by henryseg on Sat, 21 Jan 2012 17:36:33 GMT
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I was confused about that as well. The green arcs could be just straight springs, their primary purpose is to stretch, increasing the size of the grid, but wanting to shrink back again.

The curved arc form of the springs is better than just straight springs though, because the "twisting" at each of the vertices has the effect of making the springs tend to have the same amount of extension as each other, which makes the surface more uniform.

Subject: Re: Bistable auxetic
Posted by Magic on Sat, 21 Jan 2012 17:57:21 GMT
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Yes, I think I got it.
I guess it would not be bistable if the green axes were welded to the blue squares: the model would stay in its printed position (whether it was prieted in its compact configuration or extended one).
Instead with two different structures (the blue and the green) the green will always tend to its printed position (compact), while the blue would have two stable (compact) states...

[EDIT] Note that the length og the green arc must be close to the side of the blue square multiplied by square root of two.
I just watched the video: I have a lot of such "fabric-like" origami that I made a long time ago...

Subject: Re: Bistable auxetic
Posted by 32Q2 on Sun, 22 Jan 2012 13:34:56 GMT
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Good point henryseg about the mechanism here being planar.

I'm hoping though that with a large enough sheet of this there will be some interesting out of plane effects.
If different parts of the sheet are expanded by varying amounts (as would happen if there was an expanded region trapped between 2 different stable regions) then it should cause the whole thing to take on some curvature.

On a related note - I really like these sculptures by Haresh Lalvani, that work in a somewhat similar way:

That said - I do think it would also be great to try out some truly 3d auxetics. Perhaps this arrayed 'jitterbug' mechanism could be combined with the double rotary joint shown here...