Passing objects: robot-robot interaction with universal grippers
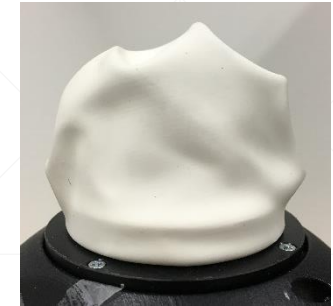
Final presentation – June 2017

Quentin Golay - *Microengineering*

Supervisors: Simon Hauser
Mehmet Mutlu
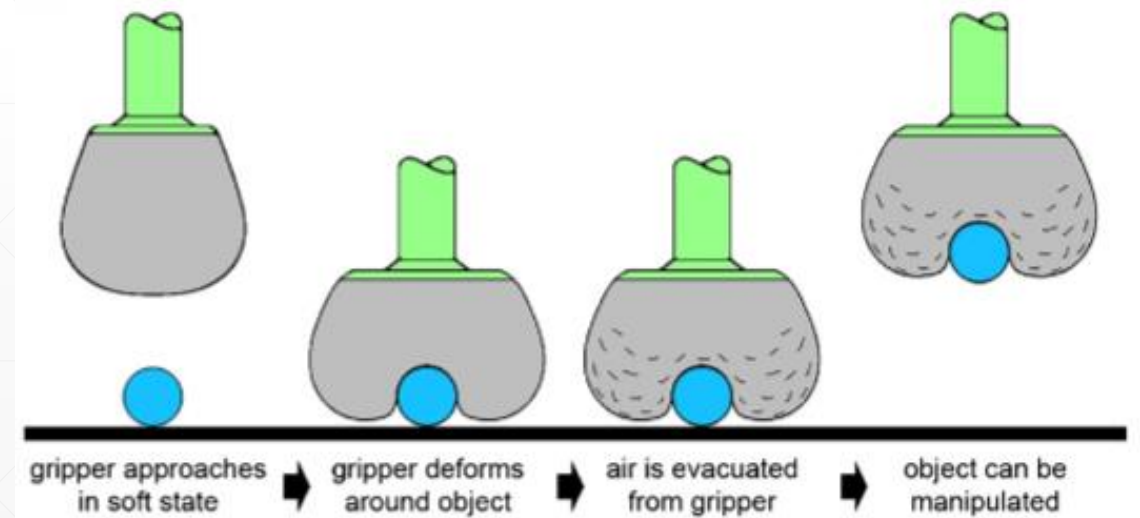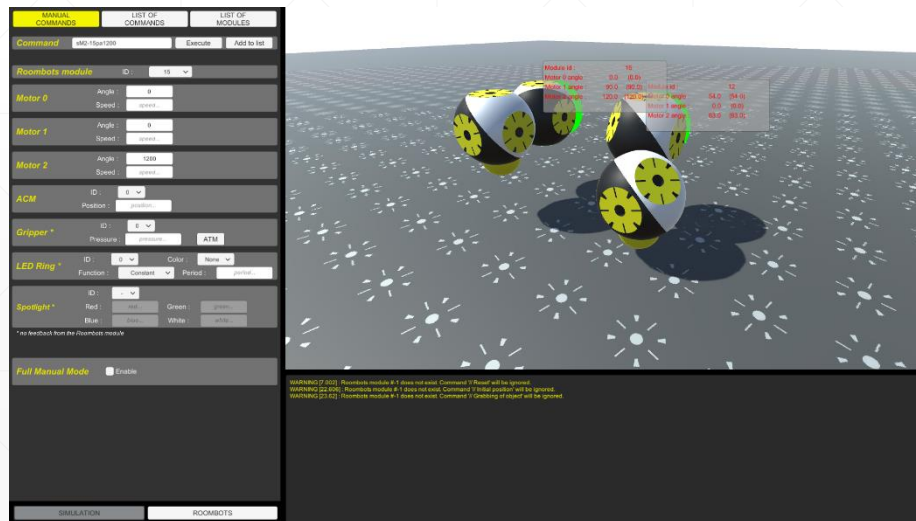
Professor: Auke Ijspeert

Reminder

- Roombots modules

- Universal gripper

- GUI

4mm cubic rubber granules

gripper approaches in soft state → gripper deforms around object → air is evacuated from gripper → object can be manipulated

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Goals

- **Study under which conditions passing works**

  - <u>Different directions</u>: upwards, downwards, left-right

  - Influence of positioning and orientation (angle) of the object

  - Alignment between modules

  - Robustness of passing strategy

- **Extend the objects that the robots are able to pass**

  - Different types of objects (daily life)

  - Can the same movements sequence be used for all objects ?
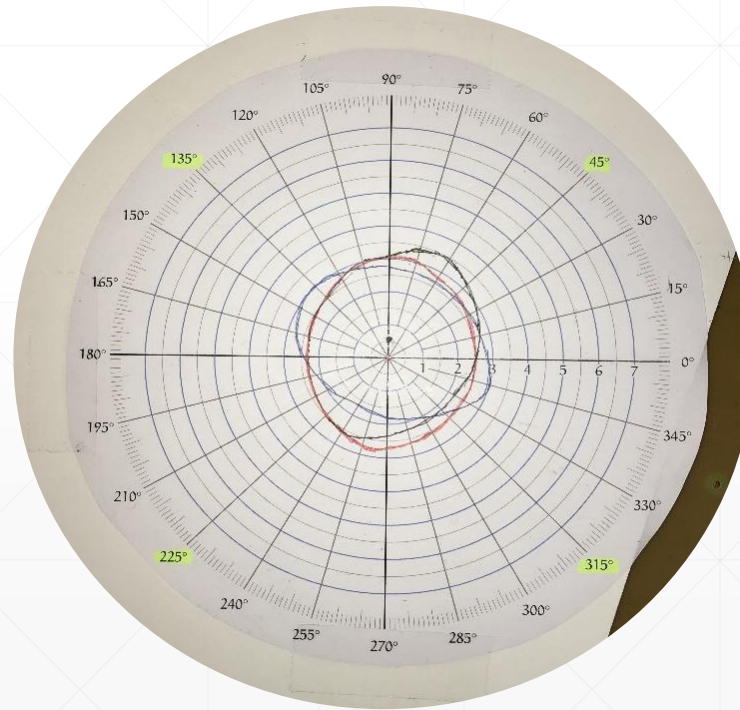
Midterm results

- No well-defined experimental setup
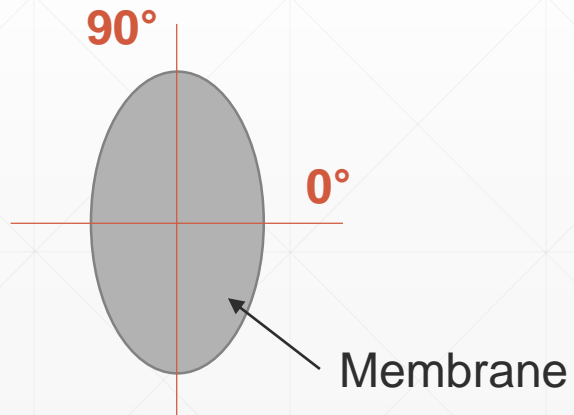
- First tries with gripping

- Low success rate
  - ~14% at best
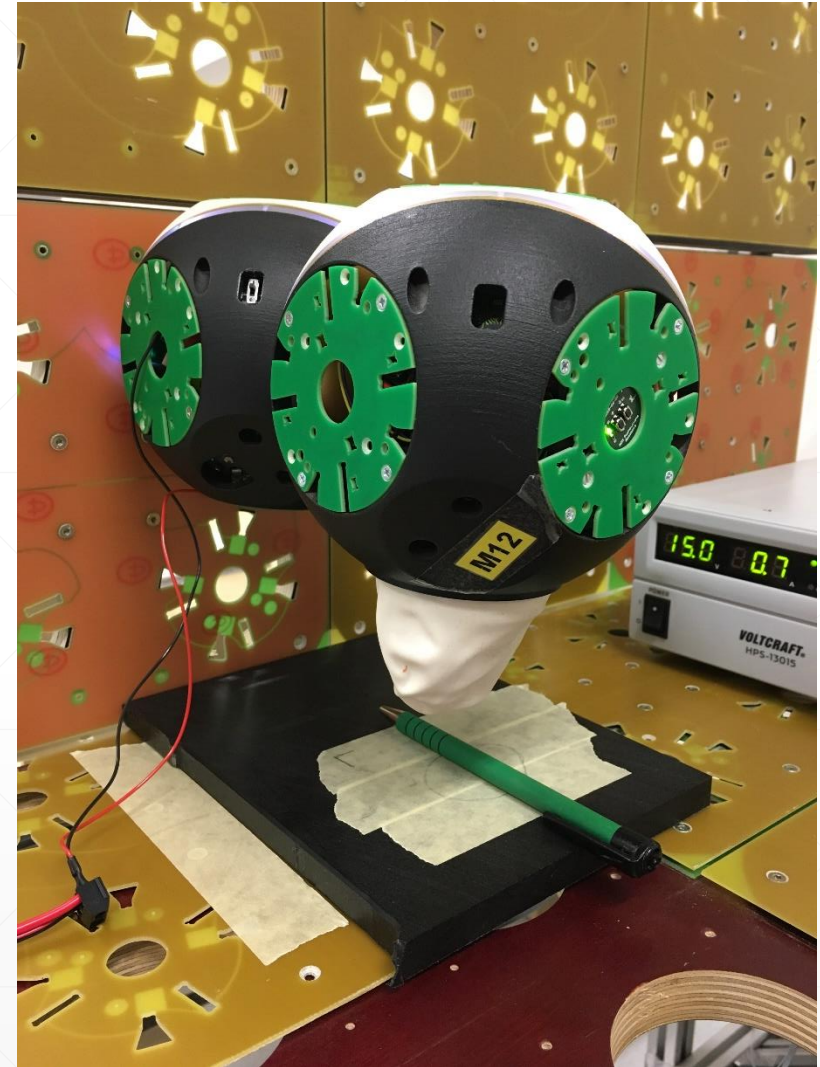
Setup

- Wall structure (passive gripping elements)

- Set of test objects

- Polar graph
  - Reference for orientations

90°

0°

Membrane

Passing objects: robot-robot interaction with universal grippers
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Gripping

- Vertical approach onto the object

- Different strategies by combining:
  - Inflation
  - Push (= application of a force)
  - Vacuum

- **Volume of granules**
  - Contraction towards open space

- **Shape and size of granules**
  - Ease of spread
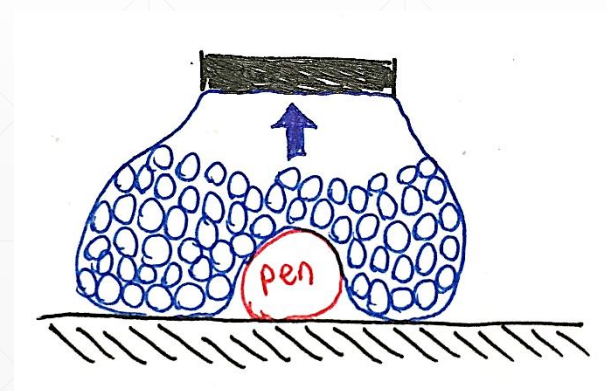
Final strategy

1. Inflate

2. Push

3. Atmospheric pressure

4. Little push

5. Vacuum

- **Success rate depends on orientation**

0°	45°	90°	135°
100%	65%	20%	75%
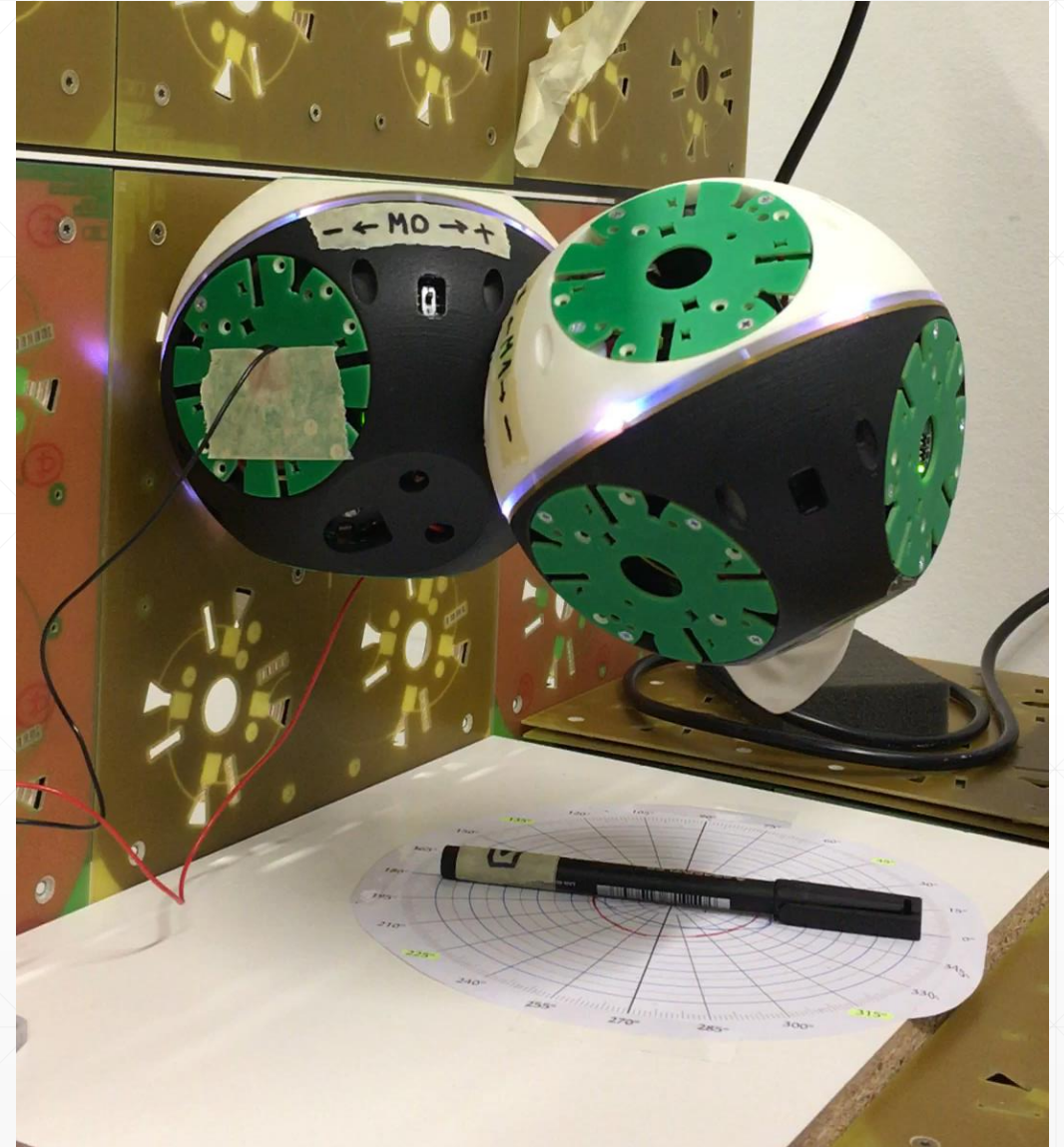
Passing
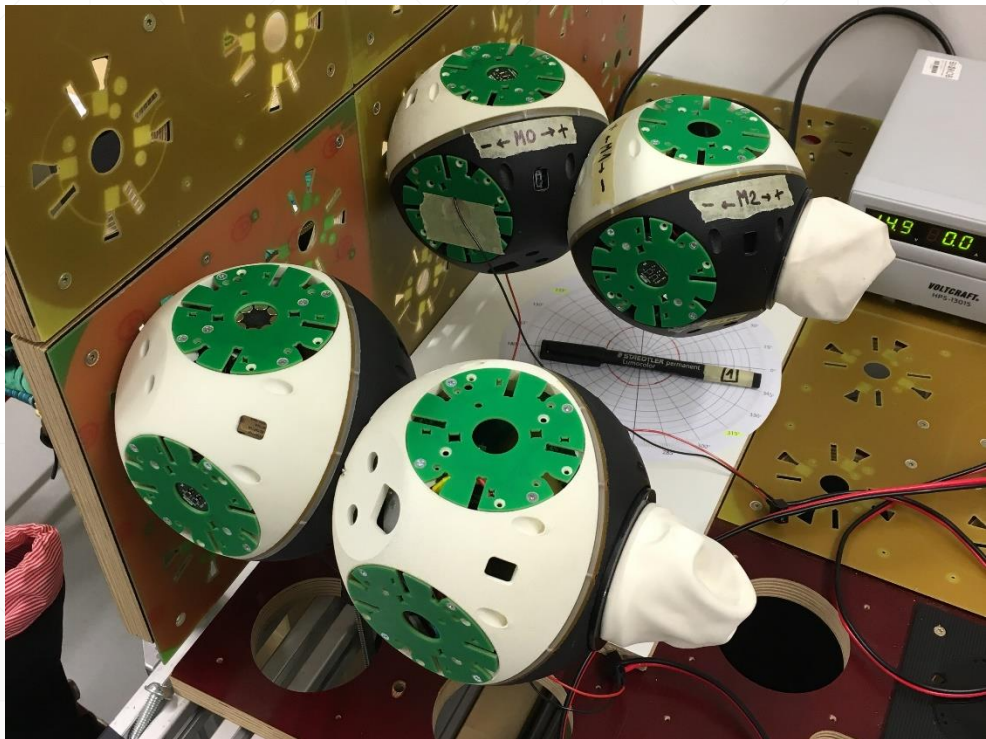
Sideways (right to left)

Upwards

Strategy

- **Object release from the first gripper to provide enough gripping surface for the second one**

- Intermediate step

- <u>Different strategies:</u>
  1. Vacuum
  2. Push – vacuum
  3. Vacuum – push – vacuum
  4. Vacuum – push - vacuum

Wrinkled profile
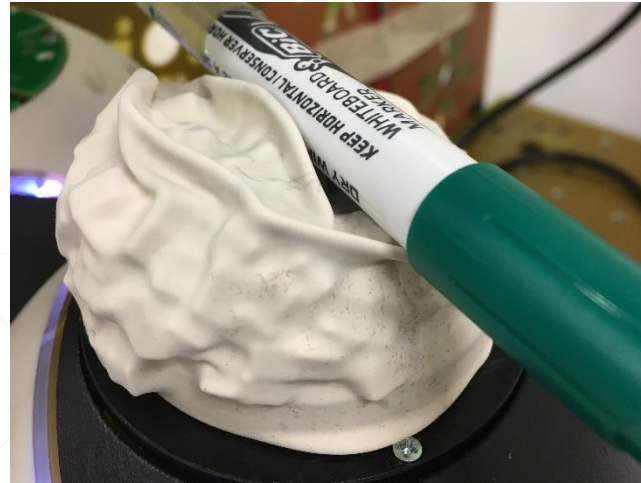
Intermingling

Folds around the object

Effects of gravity

Results

- Few successes only (both directions)

- Strategy:
  - Pen release by inflation/deflation
  - Inflate - push - vacuum (upper gripper)

- Random reliability

- **Heavily depends on the membrane**

Full of granules

- Pile-up effect

- **More force is needed to spread the granules**
  - Gripping: OK
  - Passing: PROBLEM

- Gripping force after passing is weak

- Still some random successes
  - Favorable contractions of membrane
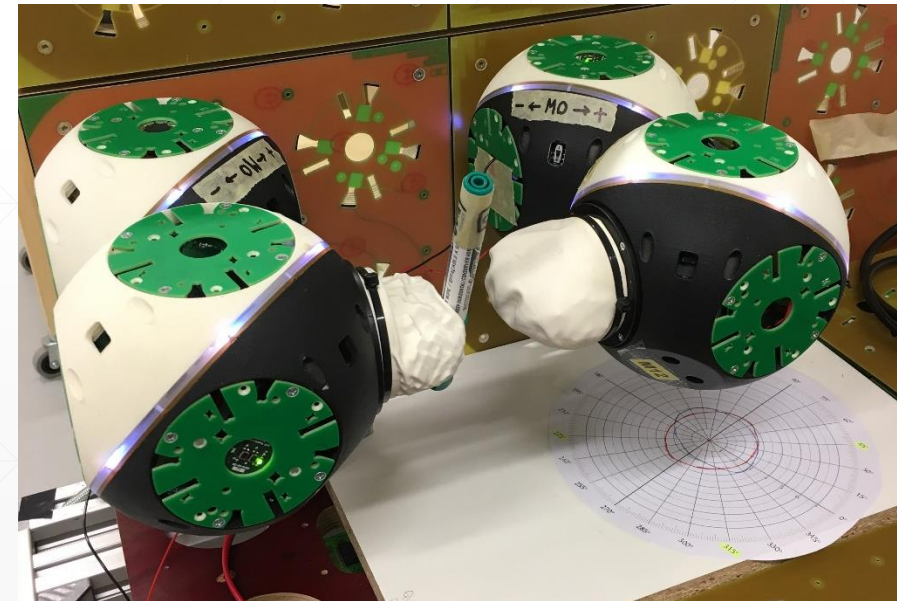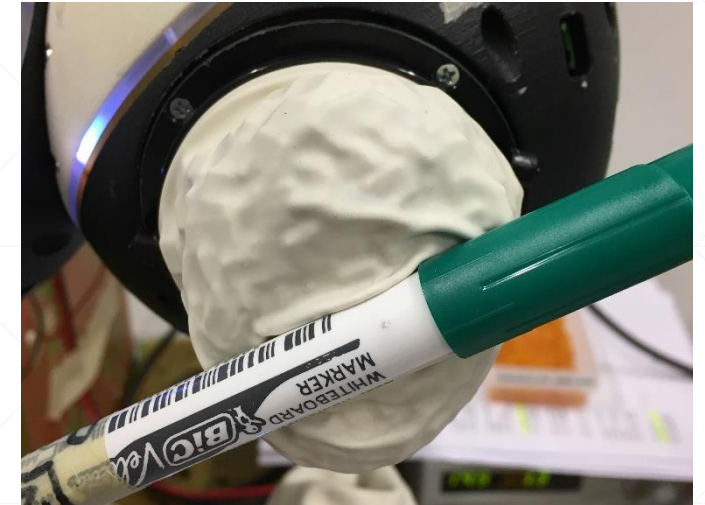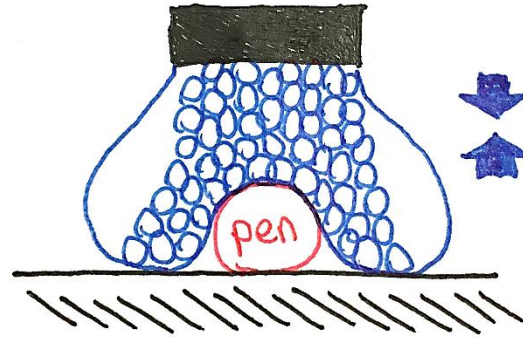
Coffee powder

- One of the first jamming material used

- <u>No compliance</u>: **all-or-nothing behavior**

- <u>Design of a new air filter:</u>
  - Cotton pad
  - Tape
  - Perforated cardboard

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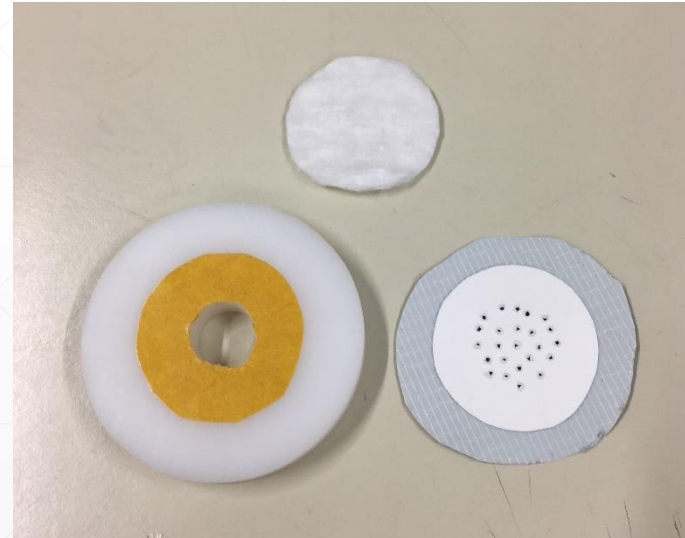
Gripping with coffee powder

- **Easier spread**

- All test objects could be picked up

- Stronger gripping force
  - Different behavior compared to granules

- Improved success rate

0°	45°	90°	135°
100%	85%	60%	100%

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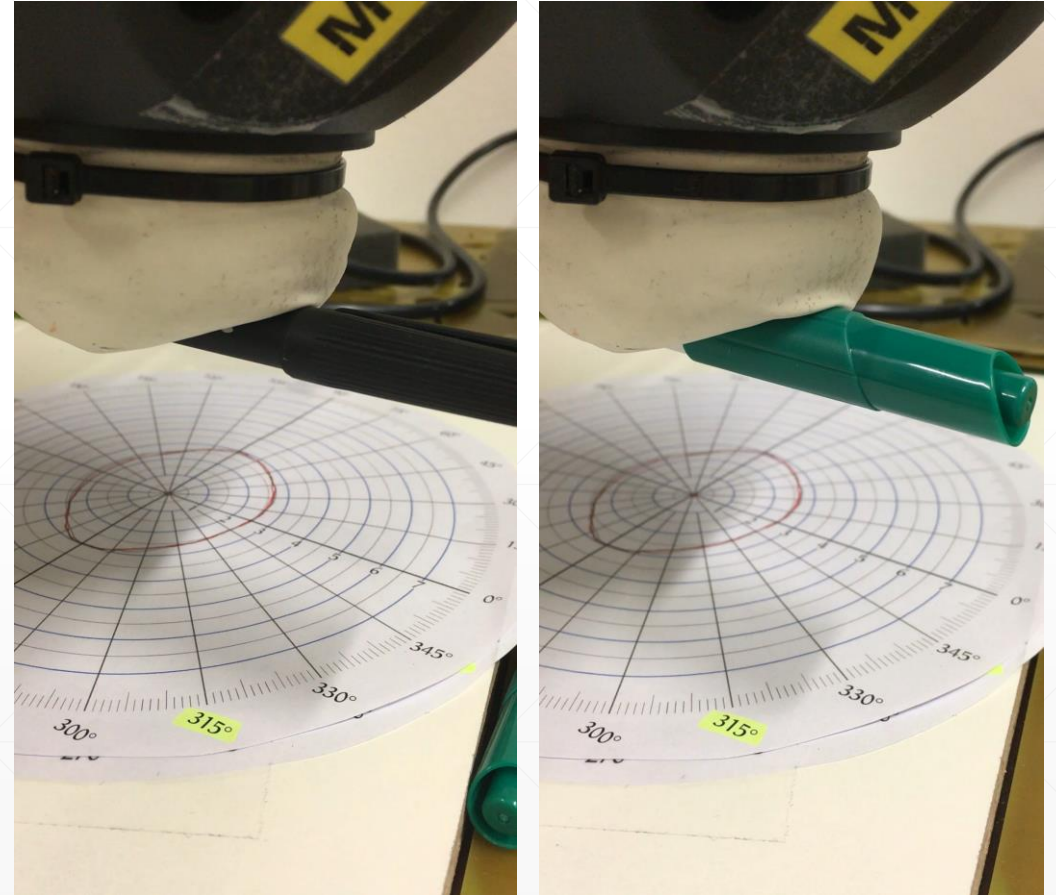
Passing with coffee powder

- **Shape-memory effect**
  - Reset maneuver

- Not enough filling ?
  - Imprint slightly too wide = no grip
  - Powder retraction under vacuum

- Few random successes again
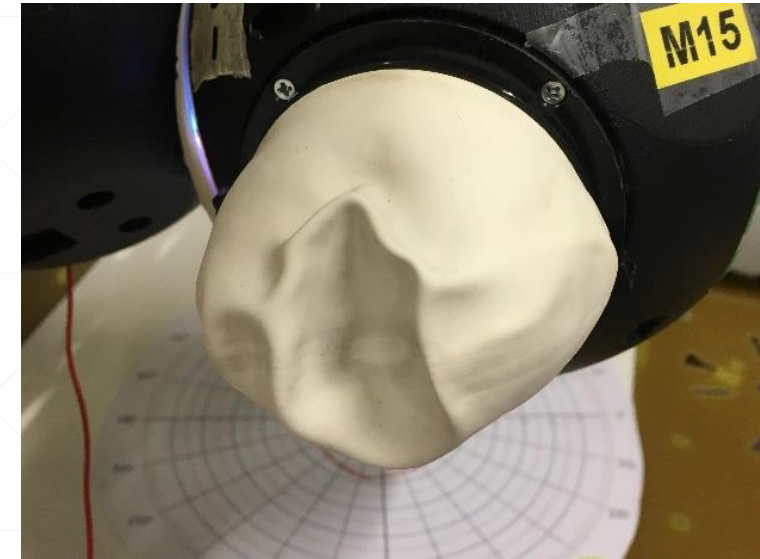
Shifted passing

- Gripping a free part of object

- **Orientation dependent**

- **Object dependent**
  - Initial gripping force
  - Position of 2nd grip

- Reliable passing
  - 3x in a row, 3 different pens

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Conclusion and future work

- Face-to-face passing was achieved a couple of times in both directions
  - **Not reliable enough for the moment**
  - **Heavily affected by the membrane and its filling material**

- Shifted passing can work reliably, but has a limited range of applications

- Spherical membranes

- Smaller and compliant granules
  - Trade-off between 4mm cubes and coffee powder

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Thanks for your attention !

Questions ?

References

- [1]   John Amend, Nadia Cheng, Sami Fakhouri, and Bill Culley. Soft robotics commercialization: Jamming grippers from research to product. Soft Robotics, 3(4):213-222, 2016.

- [2]   John R Amend, Eric Brown, Nicholas Rodenberg, Heinrich M Jaeger, and Hod Lipson. A positive pressure universal gripper based on the jamming of granular material. IEEE Transactions on Robotics, 28(2):341-350, 2012.

- [3]   Eric Brown, Nicholas Rodenberg, John Amend, Annan Mozeika, Erik Steltz, Mitchell R Zakin, Hod Lipson, and Heinrich M Jaeger. Universal robotic gripper based on the jamming of granular material. Proceedings of the National Academy of Sciences, 107(44):18809-18814, 2010.

- [4]   Theo-Tim Denisart. Hardware integration of a universal gripper to the roombot module. BioRob semester project, 2017.

- [5]   Allen Jiang, Georgios Xynogalas, Prokar Dasgupta, Kaspar Althoefer, and Thrishantha Nanayakkara. Design of a variable stiness exible manipulator with composite granular jamming and membrane coupling. In Intelligent Robots and Systems (IROS), 2012 IEEE/RSJ International Conference on, pages 2922-2927. IEEE, 2012.

Other orientations
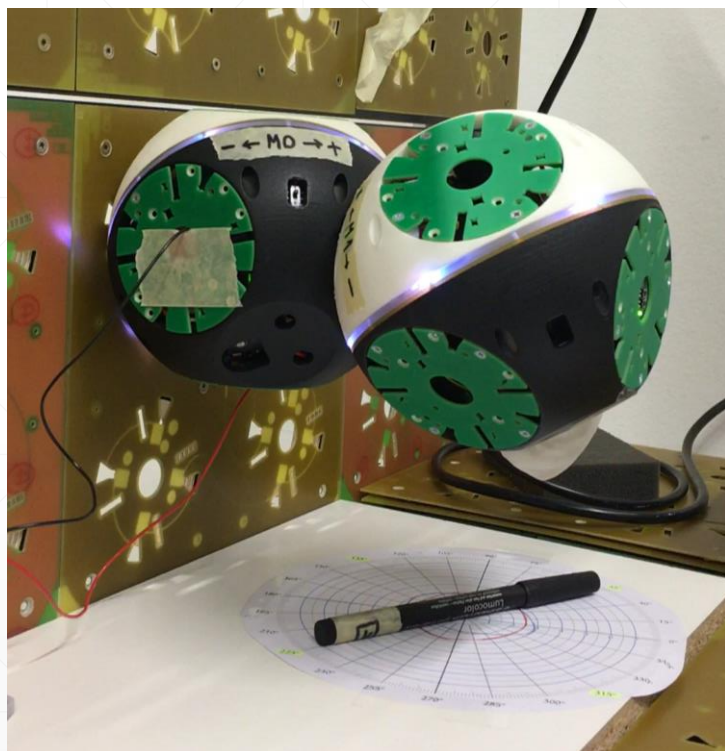
45°

90°

135°

Table 2: Results of testing the final gripping strategy.

	pen 1		pen 2		pen 3		USB stick		Success rate	Success rate (Y* = fail)
	Success (Yes/No)	Grip quality (5 = best)	Success	Grip quality	Success	Grip quality	Success	Grip quality		
0°	Y	4	Y	4	Y	5	Y	3	100%	100%
	Y	5	Y	5	Y	3	Y	4		
	Y	5	Y	5	Y	5	Y	5		
	Y	4	Y	4	Y	4	Y	5		
	Y	4	Y	4	Y	4	Y	5		
45°	N	-	N	-	N	-	Y	4	80%	65%
	Y	1	Y*	0	Y	2	Y	4		
	Y	2	Y*	0	Y	2	Y	3		
	Y*	0	Y	2	N	-	Y	5		
	Y	2	Y	1	Y	3	Y	3		
90°	N	-	N	-	N	-	Y*	0	35%	20%
	N	-	N	-	Y*	0	N	-		
	Y	1	N	-	Y	1	N	-		
	N	-	N	-	N	-	Y	1		
	N	-	Y	2	Y*	0	N	-		
135°	Y	2	Y	3	Y	2	N	-	85%	75%
	Y	2	Y	5	Y	2	Y*	0		
	Y	2	Y	2	N	-	Y*	0		
	Y	2	Y	2	Y	3	N	-		
	Y	2	Y	1	Y	3	Y	2		
Success rate	75%		75%		75%		75%			
Success rate (Y* = fail)	70%		65%		65%		60%			

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Table 3: Results of testing the chosen gripping strategy with coffee powder as membrane infill. Performance could be possibly improved for 90°angle by applying more push on the object before gripping.

	pen 1		pen 2		pen 3		USB stick		Success rate	Success rate (Y* = fail)
	Success (Yes/No)	Grip quality (10 = best)	Success	Grip quality	Success	Grip quality	Success	Grip quality		
0°	Y	7	Y	9	Y	8	Y	10		
	Y	9	Y	10	Y	9	Y	10		
	Y	8	Y	10	Y	10	Y	10	100%	100%
	Y	10	Y	9	Y	8	Y	9		
	Y	8	Y	10	Y	9	Y	10		
45°	Y	4	Y*	0	Y	5	Y	1		
	Y	4	Y	5	Y	6	Y*	0		
	N	-	Y	5	Y	3	Y	1	95%	85%
	Y	5	Y	4	Y	4	Y	1		
	Y	3	Y	1	Y	5	Y	2		
90°	N	-	N	-	Y	1	Y	2		
	N	-	N	-	Y	3	Y	2		
	N	-	Y	2	Y	4	Y	3	65%	60%
	N	-	Y*	0	Y	2	Y	2		
	Y	1	N	-	Y	2	Y	1		
135°	Y	6	Y	9	Y	8	Y	4		
	Y	7	Y	7	Y	7	Y	4		
	Y	7	Y	8	Y	5	Y	3	100%	100%
	Y	9	Y	8	Y	7	Y	5		
	Y	7	Y	8	Y	10	Y	6		
Success rate	75%		85%		100%		100%			
Success rate (Y* = fail)	75%		75%		100%		95%			

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