Toward synthetic data generation for robotic tactile manipulations

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Introduction

Data collection for tactile-based robotic manipulation plays a crucial role in improving existing models and enabling general models to perform effectively across various scenarios. These tactile sensors have been successfully employed in diverse applications, including: rich-contact tasks, grasping transparent objects, slipping detection or force-controlled grasping for fragile and deformable items. Most of these tasks rely on small datasets from real-world scenarios. Consequently, a significant limitation persists: the scarcity of data.

Background

- Large scale grasping dataset are without tactile [1]
- FEM based tactile sensor have shown good result [2]
- No automatic pipeline for generating tactile data

Contributions

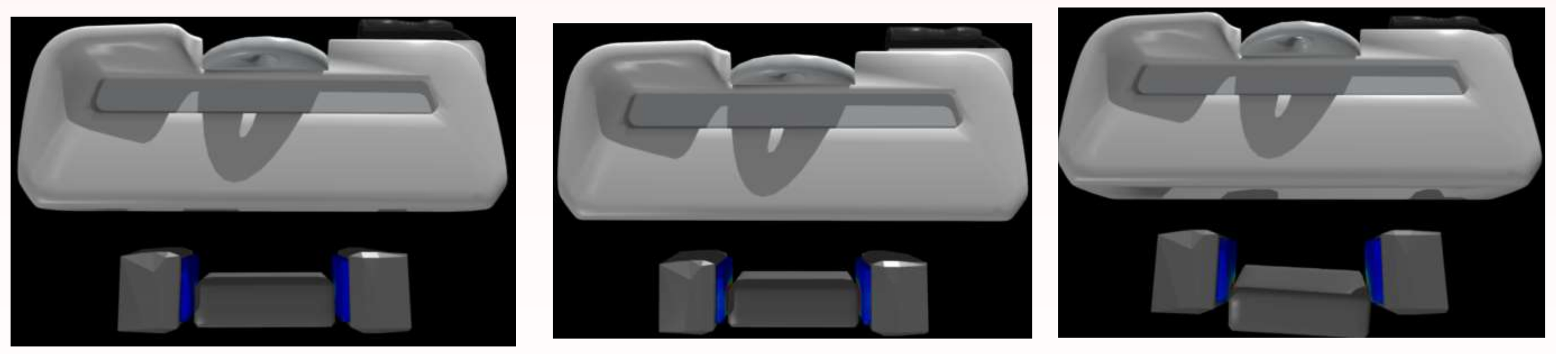
Our contributions can be resumed as :

- a pipeline for automatic tactile data generation
- integrating tactile sensors into DefgraspSim [3]
- the first FEM based simulation of the gelsight mini

Simulation pipeline

The simulation pipeline consist of

1) Closing the fingers until contact
2) Squeezing the object until force N is reached
3) Applying gravity for shear deformation and slipping



a) Initial contact b) Squeezing with 3N c) Object slipping

Fig. 1: Example of a simulated rectangle grasped with two Gel-Sight mini sensors and a panda gripper during the simulation into defgraspSim [3].

Data generated

During the pipeline numerous data is recorded such :

- Frame to frame sensor deformation, stress and forces
- Gravity and non gravity aware grasping success
- Slipping annotation by detecting changes of contact between the object and the sensor

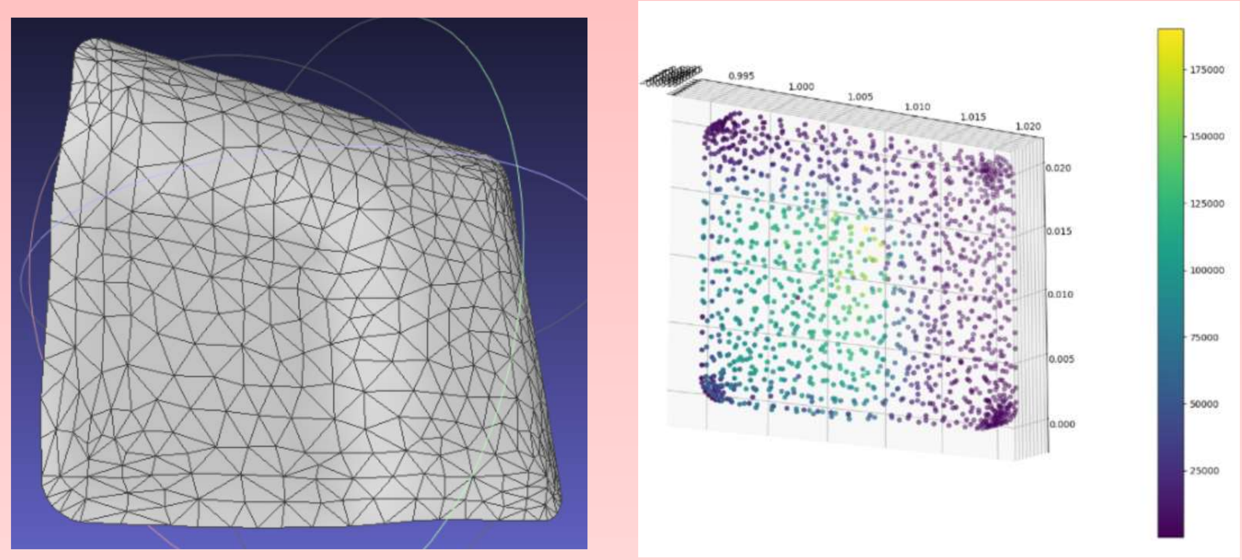


Fig. 2: For the rectangle example: (left) illustration of the recorded deformation and (right) stress applied on the sensor.

Tactile images

Tactile images are computed from the data of the simulation, secondly a texture is applied on the mesh to simulate marker based tactile images.

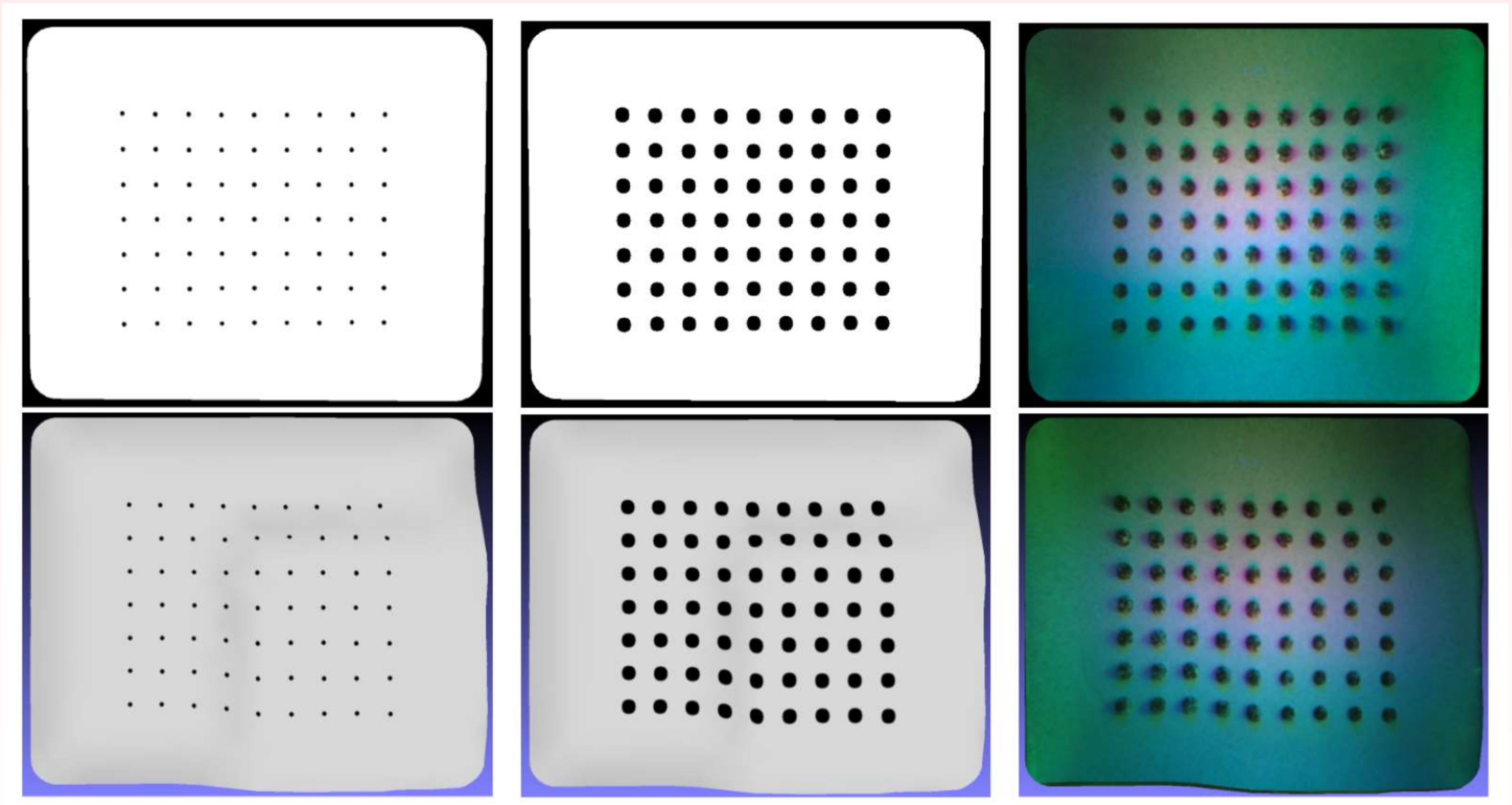


Fig. 3: Three examples of texture were applied to the tactile sensor: the left one uses a small marker texture; the middle one uses a real size marker texture; and the last one uses a real tactile image as texture. The first row shows the undeformed texture, while the second row shows the deformation induced by grasping the rectangular object

Sim2real example

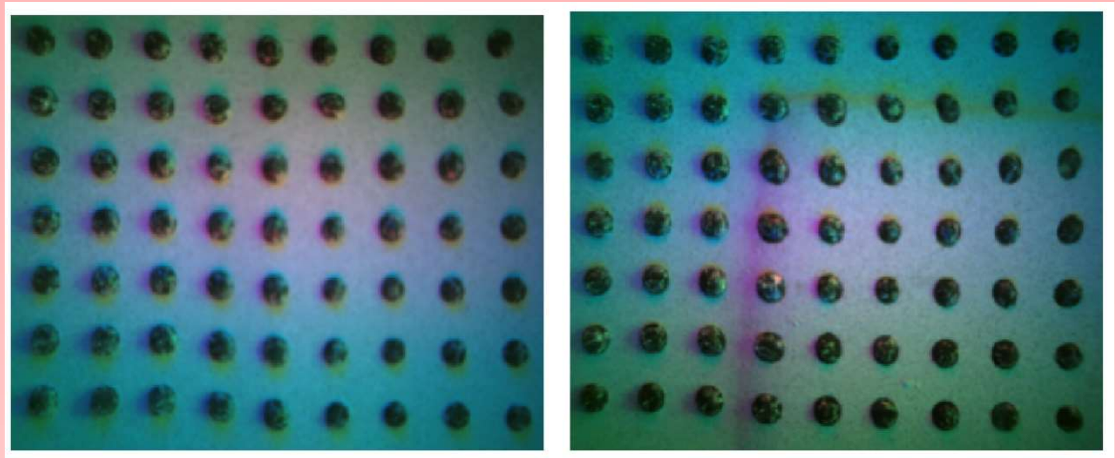


Fig. 4: Visual comparison between synthetic tactile image(left) and a real tactile image (right) for a rectangle object

Limitation

This work is a preliminary step towards generating comprehensive data for tactile robotic manipulation using Isaac Gym. Despite the high-quality output from the FEM simulation, it is computationally expensive, reducing the effectiveness of parallelization.

Future works

- More sim2real comparison need to be done
- Generate synthetic datasets for tactile based grasping succes, slipping detection or
- Show sim2real transfer of trained models to real world tactile sensor

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References

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