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Robotic Postioning of Textile Wrinkles in Sewing Using Reinforcement Learning

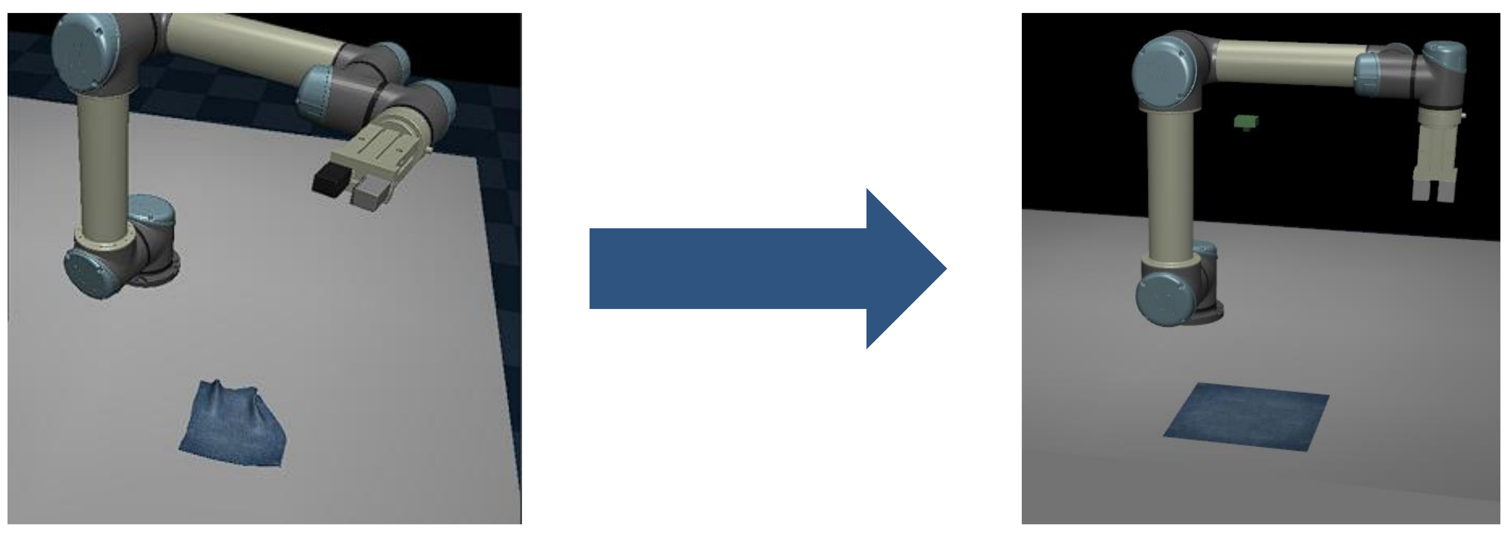
K. F. Grøntved, M. H. Bøgestrand, and J. Falk
Department of Materials and Production, Aalborg University, DK

1. Introduction

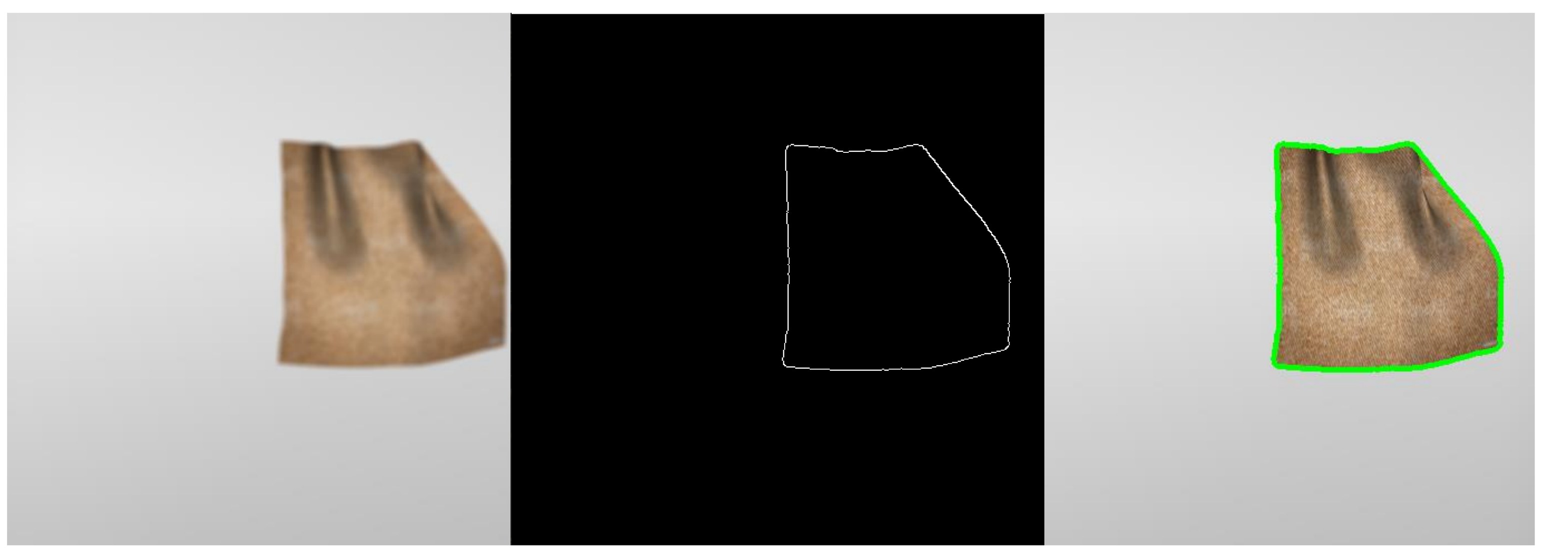
Textile industries manufacture close to 80% of the EU's textiles in developing countries where manual labour costs are low. The working conditions are distressing as poor ventilation, temperature, noise, repetitive work, and ergonomics lead to health issues for the employees. An automated sewing system could mitigate the social risks associated with the sewing, while localized production would expedite time-to-market and reduce the production of excess clothing. Not only is lifting and fixation without puncture troublesome but displacement during handling is nearly inevitable with highly flexible materials. Little literature exists on technologies for handling of textile wrinkles and the existing experimental setups are sparse in the industry.
There is an inclination in utilizing reinforcement learning for training an end-to-end control system based on trial-and-error in highly complex environments. This decreases the extensive engineering work of modelling. A RL pipeline for training an agent in positioning and handling wrinkles was proposed.

2. The proposed system

The proposed system for handling textiles to remove wrinkles from textiles in sewing is a simulated environment in Multi-Joint Dynamics with Contact (MuJoCo), where RL functionalities were developed using Gymnasium, and the training and RL algorithm was implemented using skrl. The system would then identify wrinkles and handle the fabric to remove the wrinkles.



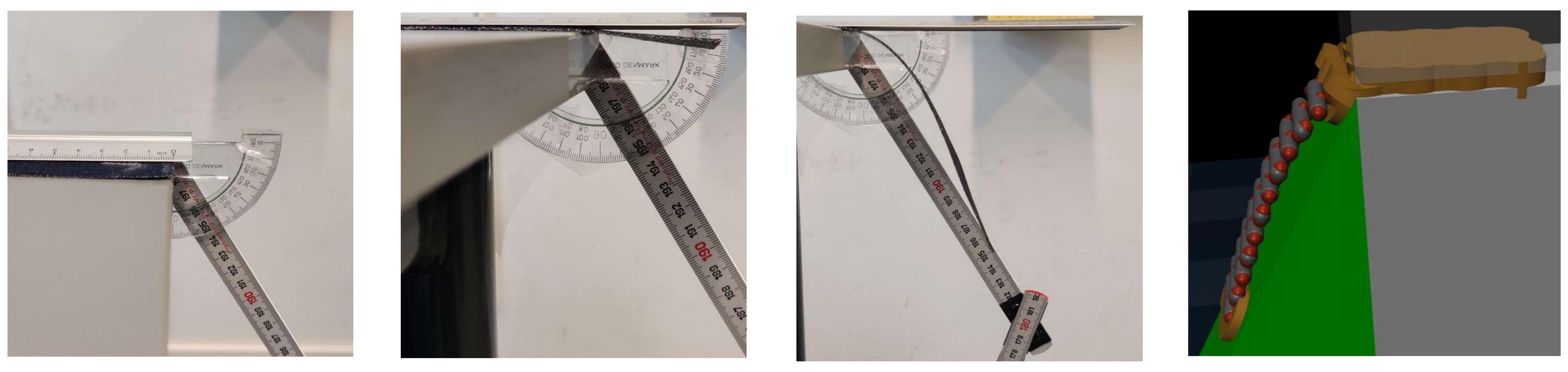
To determine if the textile was unfolded and smoothed, a vision system was made to compute the area and shape of the textile. Since the maximum area was known, the calculated area was compared to the maximum, and a reward was given based on the comparison.



The total reward given to the reinforcement learning algorithm was calculated as:
total reward = move reward * w1 + coverage reward * w2 + done reward - step penalty * w3
Where *move reward* was based on successful movement, *coverage reward* was based on vision and *done reward* is given if the textile is smoothened.

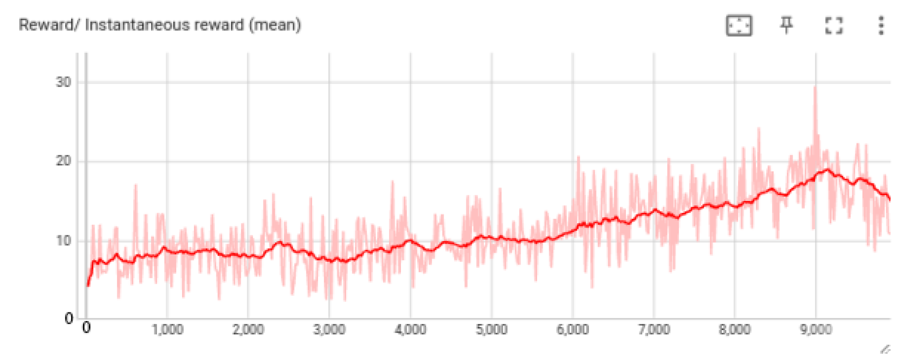
3. Testing and Tuning

To validate and get the physics of the simulated textile as close to reality as possible, a Shirley stiffness tester was made with the real and the simulated textile.

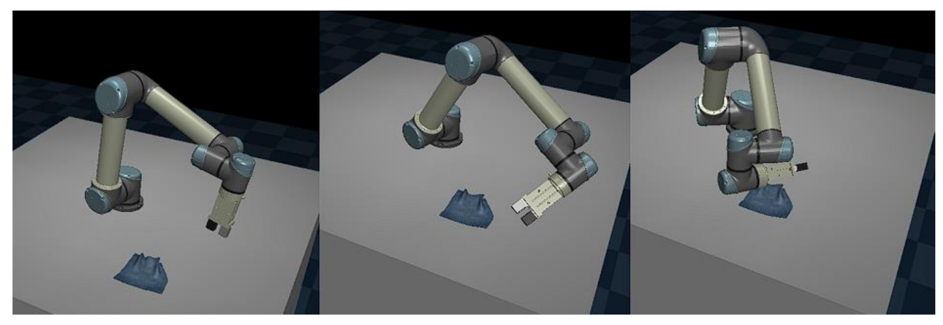


The agent was trained in multiple iterations and for each iteration multiple different hyperparameters were tuned. This was to create a training environment and setup that would make the agent learn a policy with the desired behaviour. Single agent multi-environment training was also utilized to speed up the learning process.

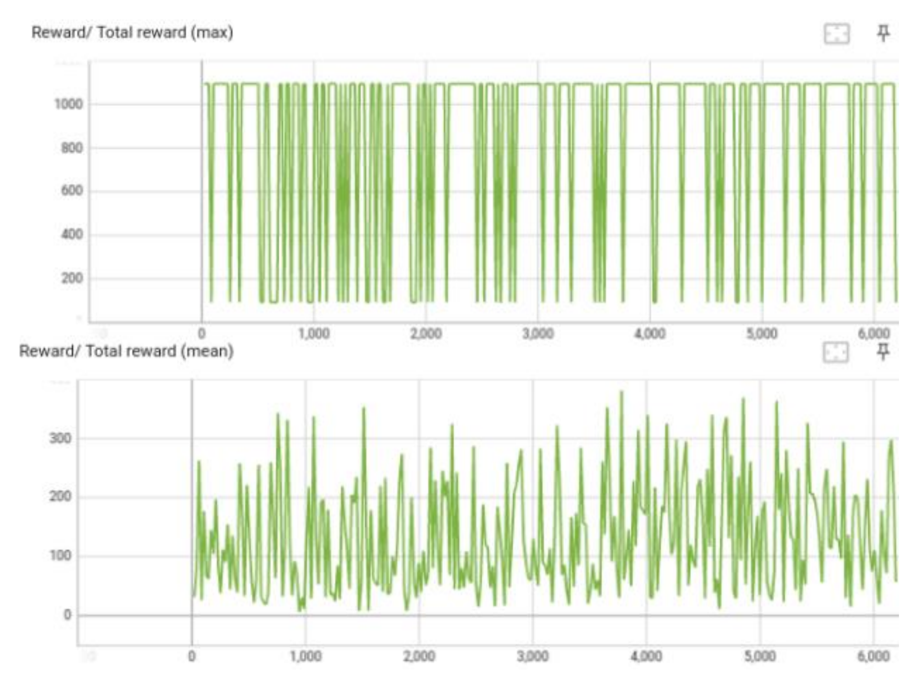
A problem that was faced was that the agent would learn to move the robot without with its surroundings based on the reward system.



Subsequently this would also have the effect of the agent not discovering that it could get a bigger reward by touching and manipulating the textile. Therefore, a version of the training environment with a new reward system was made that would only reward the unfolding of wrinkles in the textile.



This led to the agent being able to unfold the textile fully and achieve its goal. The training did not however result a training were the policy converged to a state were the behaviour of the unfolding the cloth was consistent and reliable.



4. Conclusion

Testing and tuning of reward functions and hyperparameters did not result in a policy capable of positioning wrinkles. However, the developed pipeline integrating MuJoCo, Gymnasium, and skrl proved functional and manifest testing various reward functions, algorithms, and tune hyperparameters. Moreover, the textile models were validated and fitted to the physical textiles and allowed for training on physical properties.

Acknowledgement

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