A friction reduction system for deformable robotic fingertips

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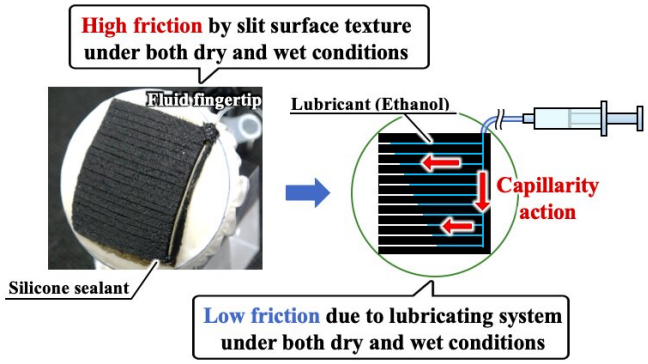


An illustration of the researchers' fluid fingertip concept. Credit: Mizushima et al.

Researchers at Kanazawa University have recently developed a friction reduction system based on a lubricating effect, which could have interesting soft robotics applications. Their system, presented in a paper published in Taylor & Francis' *Advanced Robotics* journal, could aid the development of robots that can efficiently manipulate objects under both dry and wet conditions.

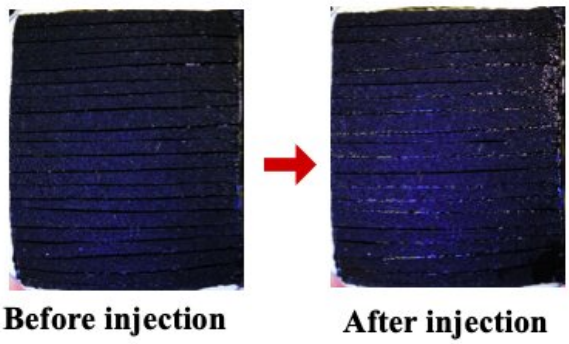
"Our previously developed surface texture or skin for soft robotic hands provides high friction under both dry and wet conditions," Tetsuyou Watanabe, one of the researchers who carried out the study, told TechXplore. "However, this high friction makes several manipulation styles (including releasing and sliding) difficult. In some cases, a grasped object sticks to the surface. To overcome this problem, we developed a new friction reduction system utilizing lubricants."

When developing their system, Watanabe and his colleagues drew inspiration from human behavior. They observed that in supermarkets people often lick their fingers to open plastic bags or containers. Similar actions are also performed when trying to pick up sheets of paper or turn the pages in a book.

The researchers found that this 'finger licking' behavior is particularly common in middle aged or elderly people, as aging typically leads to dryer skin. Younger people, on the other hand, often do not need to lick their fingers when trying to manipulate plastic or paper, because they can automatically control the skin's friction via their body's sweat mechanisms.

"Of course, the aim of licking fingers is to get high friction, and totally different from our purpose (i.e. reduction of friction)," Watanabe said. "However, normally the aim of lubricants is to reduce friction in mechanical systems. Thus, we considered the possibility of a friction reduction system that is similar to sweat control in humans."

The researchers constructed a robotic fingertip that has slits in its surface. When lubricants (e.g. ethanol) are injected around the boundaries of these slits, they permeate throughout the surface, via a capillary action.



The fingertip before and after ethanol is injected in it. Credit: Mizushima et al.

"We utilized the thin surface area including texture, and the system works on not only rigid but also deformable bodies without loss of adaptability to an object's shape," Watanabe said. "Therefore, the main advantage of our system is that surface friction can be controlled while maintaining the surface deformability and adaptability. This means that the developed system can be attached on robots with soft bodies."

In recent years, the use of soft bodies has become increasingly popular in robotics, due to their high deformability and adaptability. For instance, soft robots can move more freely in their surroundings, without presenting extensive damage when hitting walls or obstacles. In addition, soft robotic hands can adapt to an object's shape while grasping it, which enables more advanced manipulation strategies.

"Another key advantage of our system is that it works under both dry and wet conditions," Watanabe added. "It is hence very useful for robots that work in human environments, because housework is performed under both these conditions."

The researchers embedded their system into a robotic fingertip and evaluated its performance in a series of experiments that involved grasping and releasing objects. Their findings suggest that the lubrication technique they developed can effectively reduce friction under both wet and dry conditions.

"As you can imagine from the human behavior of licking fingers, water can increase friction and in some cases allow the skin to stick to surfaces," Watanabe said. "In contrast, ethanol reduces friction. The important factor for friction reduction is the spreading coefficient closely associated with capillary forces (i.e. surface tension)."

In this context, a low capillary force entails the easy diffusion of liquid throughout a surface. Using ethanol, which has a low capillary force, the researchers were able to reduce friction and easily spread the lubricant throughout the fingertip's entire surface. A further advantage of ethanol is its high volatility, which considerably reduces tact time.

"We also observed that to facilitate the function of our system, the surface should not be completely smooth," Watanabe added. "A surface that is a little bit rough or uneven can further improve its function."

Robots could soon support humans in a variety of settings, for instance helping them with housework or providing nursing care. As these tasks are generally performed under both dry and wet conditions, the researchers' friction reduction system could prove very helpful.

"Handling and manipulating objects are the main targets for our research and then the tasks including such actions are the targeted applications," Watanabe said. "A few examples are folding clothes, cooking, washing, etc."

In the future, the lubrication system developed by Watanabe and his colleagues could inform the development of soft robots that can manipulate objects more effectively, in both dry and wet environments. The researchers are now planning further research aimed at delineating and broadening their system's possible applications.

"Currently, we have only combined fingertips with our system," Watanabe said. "As a next step, we would like to apply our friction control system to a robotic hand. Moreover, the applications for the system are still unclear, so we would like to outline appropriate methodologies for real operations, such as folding or cooking."

More information: Deformable fingertip with a friction reduction system based on lubricating effect for smooth operation under both dry and wet conditions. DOI: 10.1080/01691864.2019.1608299 . https://www.tandfonline.com/doi/abs/10.1080/01691864.2019.1608299

Surface texture of deformable robotic fingertips for a stable grasp under both dry and wet conditions. DOI: 10.1109/LRA.2017.2717082. https://ieeexplore.ieee.org/document/7953560