THE UNIVERSITY OF TENNESSEE CHATTANOOGA
College of Engineering and Computer Science

Robotized Automation of Lipid Bilayer Deposition and Contact Angle Measurement

Victoria Martino, Miguel Mariscal, Dajiah Platt, Hope Hunnicutt, Dr. Khalid Tantawi
Department of Engineering Management and Technology, UTChattanooga

2021 Reimagining Innovation TECHNOLOGY SYMPOSIUM

Summary

Contact angle measurement is a commonly used technique to measure the wettability of a solid surface. The technique is highly susceptible to error when conducted by a human operator. In this project, the experiment is robotized to increase accuracy, in which the Denso COBOTTA robot is used to dispense pure liquid drops onto a variety of surfaces in order to measure the contact angle for each surface. The experiment is currently being expanded for robotized deposition of lipid bilayer membranes.

Motivation

The motivation for this project is to reduce the errors when performing a contact angle measurement and deposition of a lipid bilayer membrane on a surface.

We will be able to avoid errors by programming a collaborative robot to dispense a drop of pure liquid on a solid surface. The robot being used for the experiment has a positioning repeatability of 50 micrometers, which can result in a significantly higher accuracy than if the experiment is conducted by a human operator. than Using a robot will allow for consistency in measurements.

Questions

What is the improvement in accuracy when the contact angle measurement is conducted using a robotized process rather than by a human operator?

Project Description

In this project, the Denso COBOTTA collaborative robot was programmed to utilize its attached gripper to deposit drops of pure water onto different surfaces for contact angle measurement. The surfaces include polished silicon, and vapor-deposited gold layer on silicon. The surface roughness of the surfaces was less than 5 nm. The robot has a positioning repeatability of 50 nm and can carry a payload of 0.5 kg. The robot's 2.5 MP mounted camera will be used to take images from the side and calculate the contact angle the liquid makes on the surface. The robotized data will be compared to the measurements taken from a human to determine accuracy and repeatability of results.

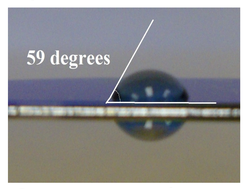
Methods & Materials

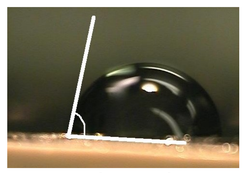
A drop of pure water is despensed by a syringe on a clear surface that is cleaned with isopropanol prior to doing the experiment. Samples of polished silicon, unpolished silicon, glass, silicon nitride, and gold-plated silicon are used as test surfaces. The fluids used for the contact angle measurement is pure water.
The robot's vision system will be positioned via the Denso COBOTTA's arm to do the measurement.

Results and Discussion

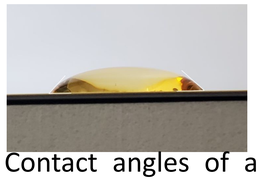
We programmed the Denso COBOTTA robot to dispense pure water drops on different surfaces to perform the contact angle measurements. The robotized experiment could be repeated with consistent results while the human results can suffer from errors primarrily positioning accuracy, which can alter the surface tension, and consequently alter the results. This is in addition to the possiblity of damaging the lipid bilayer membrane that is deposited on the surface.
There is also the fact human hands are notorious for being unsteady. Shaky hands will lead to varying surface tensions of each drop dispensed on the surface.

Although hysterisis is commonly known to affect contact angle measurements [4], other factors such as inaccuracy in dispensing the liquid, or lack of repeatability in the pumping or positioning of the syringe with respect to the surface can affect the results. The figures below show contact angle measurements conducted on a polished silicon surface.





Contact angle measurements conducted on a polished silicon surface with a lipid bilayer membrane deposited on its surface.



Contact angles of a water drop on a polished surface of silicon (right) and thermally-evaporated gold on silicon (Left).

Conclusion and Future Perspectives

In this project we robotized the process of conducting contact angle measureents in order to increase accuracy and repeatability. We used the six-axes Denso COBOTTA intelligent robto, which has a ±0.05 mm positioning repeatability.

In the next set of experiments, the robot will be used to carry out experiments in which lipid bilayer membranes will be deposited using Montal-Mueller method.

References

[1] Contact Angle Fundamentals, Ranowsky, A. (2019): https://www.cscscientific.com/csc-scientific-blog/contact-angle-fundamentals

[2] Contact Angle Method of Natural Materials, Zhao, T; Jiang, L (2017): https://www.cscscientific.com/csc-scientific-blog/contact-angle-fundamentals

[3] Membrane Characterization, R.S.Hebbar; A.M. Isloor; A.F. Ismail (2017): https://doi.org/10.1016/B978-0-444-63776-5.00012-7

[4] D.Y.Kwok, A.W.Neumann, Contact angle measurement and contact angle interpretation, 1999

Acknowledgements

The funding for this research is credited to the National Science Foundation Award number 20000685, and the UTC Faculty Award for Spring 2021.