Smartphone-based Plasmonic Sensing for Respiratory Diseases

By: Bryan Hong, Isabella Liu, Joy Ting, Julia Pan, Rishi Rai, and Luke Ting

Adviser: Dr. Zhenpeng Qin **Graduate students:** Tingting Zhang, Yaning Liu

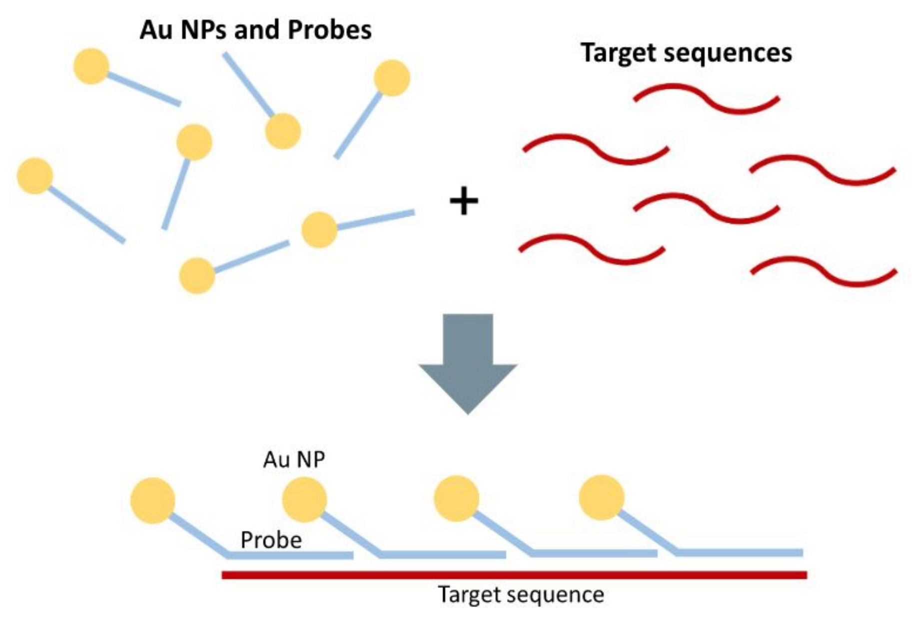
Overview

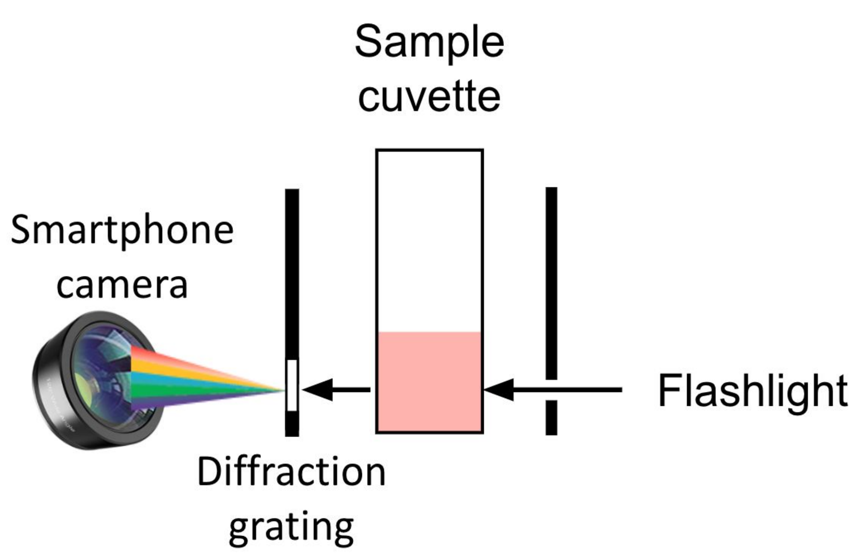
We created a rapid diagnostic test that produces accurate detection results for respiratory viruses including COVID-19. Users only need a smartphone and simple apparatus. It is user-friendly, quick, and cheap, unlike the nucleic acid test, and more reliable than the antigen test.

Motivation/State of the Art

Ordinary antigen-based tests are 30% less effective for early detection and can be inaccurate. Nucleic acid based tests require expensive equipment and can take multiple days to obtain results.

Smartphone based nucleic acid detection platforms, on the other hand, are widely available. Smartphone based detection is faster, easier, cheaper, and more accurate.





Progress Made

- We used the optical properties of gold nanoparticles, meaning larger nanoparticles absorb longer wavelengths of light. The nanoparticles attach to short nucleotide sequences called probes, and when they bind to the target sequence, the nanoparticles aggregate. The clumps of nanoparticles act as a larger nanoparticle, causing the absorption spectrum of the colloid to change.
- We synthesized gold nanoparticles at four concentrations for each virus using sodium citrate, hydroquinone, chloroauric acid, gold seeds, and pure water. We combined them in a flask on a magnetic stir plate, left it overnight, and prepared a buffer.
- We then used a smartphone-based spectrometer to get more accurate results than the naked eye. We put a phone in the camera holder and turned on the flashlight. The emitted light passed through the optical fiber and through the cuvette containing a combination of nanoparticles and viral DNA. Some light was absorbed, while the rest traveled through the camera fiber and hit the diffraction grating.
- The target sequence in the virus DNA bound to the probe, causing a color change. We found that the 50 nanometer probes resulted in a more noticeable color change than the 100 nanometer probes, making the 50 nanometer probes more suitable for use.

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Intellectual Merit and Broader Impacts

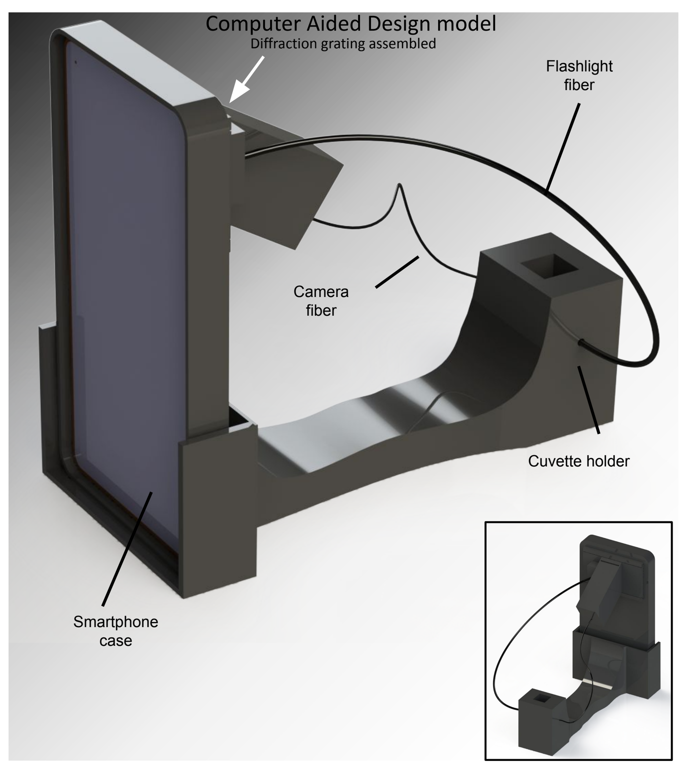
Although we used the smartphone to detect the presence of target virus DNA, we can also use it to detect other molecules, such as proteins or antibodies.

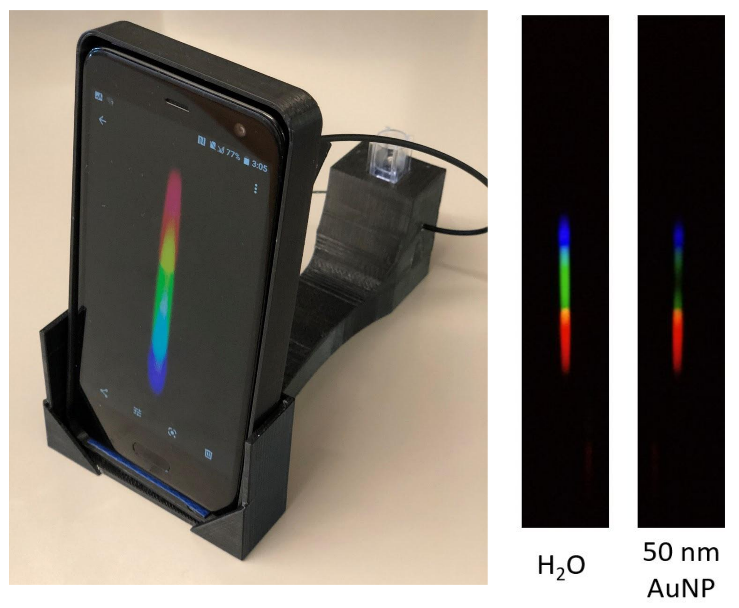
In the future, we plan to do multiplex detection (multiple targets per test), create a microfluidic chip, and optimize the smartphone apparatus design (put optical fibers securely inside the case and make it compatible with different models of smartphones).

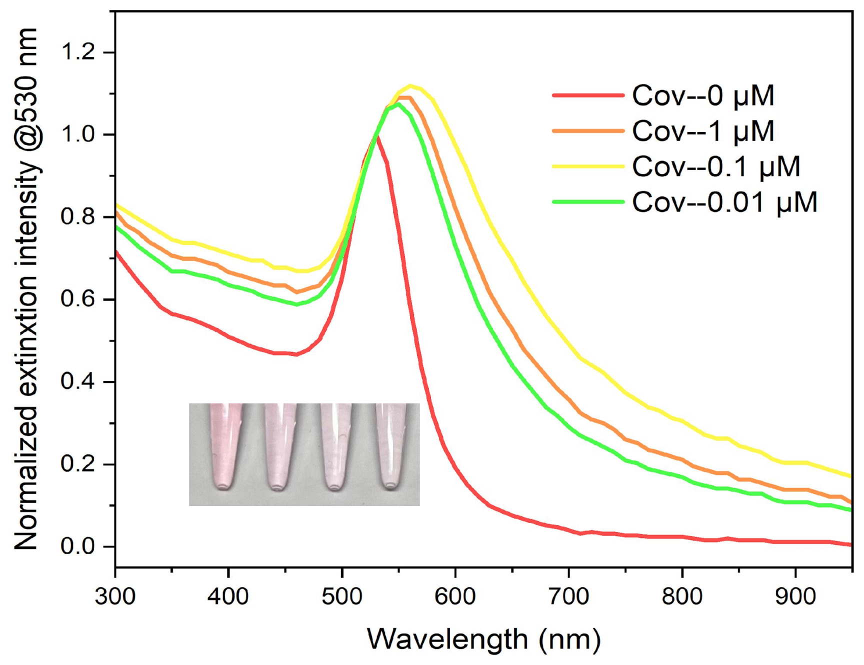
Research Plan

- 1: Research the fundamentals of current nucleic acid-based detection systems, plasmonic nanoparticles
- 2: Synthesize gold nanoparticles; oligo-particle conjugation; nucleic acid hybridization assay operation.
- 3: Create basic design and fabrication process of optical systems, optical pathway design and spectral measurements.
- 4: Use MATLAB for colorimetric imaging processing and data analysis.
- 5: Summarize results and prepare presentation.

Illustrative Figures







Conclusions

There is a noticeable color change when the target DNA is added to the nanoparticles. The peak wavelength shifts to the right and the entire graph broadens.

The color change can also be detected by the naked eye.

UT DALLAS
The University of Texas at Dallas