**Background Reading**

Design of a robot to assist nasopharyngeal swap sampling

Name: Saad Abuzaid Saad

Registration Number: 1906184

Supervisor: Jichun Li

Degree: BEng Computer with Electronics Engineering

Contents

[1.1 Introduction 3](#_Toc85076725)

[1.2 Nasopharyngeal swab sample 3](#_Toc85076726)

[1.3 Why would you need a robot to do nasopharyngeal swab sample 4](#_Toc85076727)

[1.3.1 Human Errors 4](#_Toc85076728)

[1.3.2 Distance between nostril and upper nasopharynx 4](#_Toc85076729)

[1.3.3 Robot accuracy 4](#_Toc85076730)

[1.3.4 Is it infectious or unsafe? 4](#_Toc85076731)

[1.4 Similar projects 5](#_Toc85076732)

[1.4.1 Design of a Low-Cost Miniature Robot to Assist the COVID-19 Nasopharyngeal Swab Sampling technique [10] 5](#_Toc85076733)

[1.4.1.1 Advantages 5](#_Toc85076734)

[1.4.1.2 Disadvantages 5](#_Toc85076735)

[1.5 What is my technique 5](#_Toc85076736)

[References 6](#_Toc85076737)

# Introduction

4 years ago, corona virus hits the world, forcing everyone to stay at home, shutting down a lot of businesses, and mainly stopping the world from doing anything but remotely. As always, human start looking for solutions on how to bear with this virus, and go back to our ordinary lives, and to get past this phase, because the world literally stopped, and people were forced to stay at home. Afterwards, we came up with the covid tests to test if you carry the virus. Nasopharynx swab sampling is one of the most effective testing criteria. As human, we are always looking for robots to handle these kind of jobs that can be infectious, and include mundane tasks. This project is a robot that will help with the nasopharyngeal swab sampling.

# Nasopharyngeal swab sample

Two of the most effective ways in terms of time, and cost are Nasopharynx, and Oropharyngeal swabs, but studies proved that Nasopharynx swab results can be more accurate than Oropharyngeal swab[1]. The patient should be sitting with the head straight and not tilted to one side. In this position it's easier to follow the nasal floor, which is perpendicular to the axis of the face. It may be useful to ask the patient to rest their head on the chair's head support, to limit a reflex backwards movement of the head during the swab. Children are sat on their parents’ knees who should have one palm on the forehead the other hand around both arms. Adult patients should be wearing a surgical mask but also children old enough to do so (usually from 5–6 years old). Patients should position the mask just under the nose to cover the mouth, to protect from droplets in case of coughing or sneezing caused by the swab. In case of important rhinorrhoea, the patient should be asked to blow their nose prior to the test. The caregiver should be positioned on the side of the patient to limit exposure to droplet projections. Then, the tip of the nose should be lifted to identify the area where the swab should be gently inserted. The swab should be held like a pen. The key point is to have two fulcrums (the nasal floor and the nasal septum) that guide the progression of the swab through the nasal cavity until a resistance is encountered indicating contact with the posterior wall of the nasopharynx. As such, the inclination of the swab should be in the same plane as that of the nose and the ear. The distance between the nostril and posterior wall of the nasopharynx is between 8 and 10 cm in adults. In the child, the nasal cavity is slightly shorter (6–7 cm). Usually there is a mark on the tip of the swab that indicates the right length to be inserted (although it is not always present). Gently rub and roll the swab. Leave the swab in place for several seconds to absorb secretions. Slowly remove the swab while continuing to rotate it. If the tip of the swab is inserted without following these two anatomical marks, the inferior or middle turbinate may be scraped which is painful limits the progression to the nasopharynx [2][3].

# 1.3 Why would you need a robot to do nasopharyngeal swab sample

## 1.3.1 Human Errors

We humans are not machines, we can have our errors, and mistakes; as a result, humans taking nasopharyngeal swab sample can lead to complications seldomly, which still can happen. A study conducted at Finnish institute of Health and Welfare by screening, and monitoring the nasopharyngeal swab sampling carried at otorhinolaryngology emergency department (ED) of Helsinki University Hospital Department of Otorhinolaryngology–Head and Neck Surgery between March 1 and September 30, 2020; during the 7-month study period, 643284 nasopharyngeal swab sampling were performed. Eight complication-related visits (7 females, 1 male; age range, 14.0-78.6 years; mean [SD] age, 39.5 [20.9] years) were identified in 2899 otorhinolaryngology ED patients—4 nasal bleeds and 4 broken swabs, all occurring immediately after sampling. None of these 8 patients tested positive for COVID-19.

The frequency of complications requiring treatment in the ED was 1.24 per 100 000 performed SARS-CoV-2 tests. The broken swabs were removed via nasal endoscopy under local anaesthesia, whereas the nasal bleeds required medication, numerous nasal packings, and surgical and endovascular procedures and led to fatal risk, sepsis, and blood transfusions. Half of the bleeds were potentially life threatening (haemoglobin level fell below 6.5 g/dL). Massive bleeding complicated localization of the bleeds. Infections, as well as intranasal adhesions and septal perforations, likely resulted from the repetitive nasal packings [4].

## 1.3.2 Distance between nostril and upper nasopharynx

The distance between your nostril, and upper nasopharynx, which is from tip of your nose to the desired place in which you want to get the sample from, is somehow similar between people; this distance in female body is 9.4 ± 0.6 cm, and 10.0 ± 0.5 cm in males [5]. This would be helpful for robot implementation.

## 1.3.3 Robot accuracy

There are many types of robots that can be implemented in this field, and their accuracy all varies, but they all are accurate to the nearest 1mm. In a study conducted at Department of Computer Science VII, Technical University Dortmund, the accuracy of leap motion controller differs when the robot is in static motion, or moving. In case of static position for instance, the deviation of the desired point, and actual point on x-axis is less than 0.17mm, and on y-axis is less than 0.20mm.[7]

## 1.3.4 Is it infectious or unsafe?

One of the problems we might face, is that the robot’s grip will be exposed to the person being tested, in which case the virus can be transferred to the robot’s grip, and the grip can infect the next patient; as the virus can last for up to 72hours on the grip, the amount of time that the virus lasts on surfaces varies depending on the virus, and the material [8][9]. This problem can be fixed by disinfecting the robot’s grip, we can do so automatically, using another robot, or set-up, or we can assign people to be responsible to disinfect the robot between patients, to not pass the virus to other patients.

# Similar projects

## Design of a Low-Cost Miniature Robot to Assist the COVID-19 Nasopharyngeal Swab Sampling technique [10]

This is one of the few projects that you can see on the internet, as the others were either accessed through subscriptions, or was irrelevant. This project focused mainly on its cost, they used light components, and printed 3d grip to hold swab. The main technique is the robot consists of two segments, one is to control its position, height, and the other segment which is the grip to control the angle. They have the patient seated in a specific way that suits the robot setup; the swab is actually placed in the robot’s grip by someone, either the assistant, or the patient himself, but not automatic in anyway. When you place the swab in the robot’s grip it applies the pressure needed to hold the swab, and then it uses a device that exposes the LED light, and measures the reflected beam, and it varies according to the reflecting object, and distance, which will be used to calculate the distance for the swab to reach nasopharynx, and to calculate the initial angle of the swab to enter the nose.

### Advantages

One of the advantages of this project is its cost. The developers really cared to develop a robot that would be accessible to nearly every organization, and country. Also, this robot is considerably light weight compared to other robots in the field; the total weight of the functional part is 0.23kg, which is quite good. The robot can be very accurate, and effective with good management.

### Disadvantages

The main reason people favour this robot over human force is that it should be on full automation, it doesn’t require any human interaction to work, but in this case it doesn’t; someone is required to place the swabs in the robot’s grip. Also, it doesn’t navigate to the nasal passage automatically, it needs someone to navigate it, as it is connected to a phone application through WIFI, for someone to navigate the robot’s grip to place the swab on the patient’s nostril. Moreover, it might not be safe to use this robot infection-wise; it can carry the virus on the robot’s grip, and get transferred from one patient to another, so you might require someone to disinfect the robot’s grip after every patient.

# What is my technique

I will be more concerned about full automation, and safety. First, I will try to automate the swab placement in the robot’s grip. Also, to detect the patient’s nostril, I will use computer vision to detect the patient’s face first, and then the nostril, which I will use to calculate the position and angle needed from the robot to place the swab on patient’s nostril. Moreover, I will try to find a way to disinfect the robot’s grip automatically, either by setting up a hygienic program after each patient, or putting disinfecting cover on the robot’s grip. Finally, I will try to have an interface for this robot, either by setting up components that we can connect to our phones through WIFI, or can set a screen on the robot that is mainly for screening the process.

# References

[1] X. Wang, Li Tan, XU wang, Y. Lu, L. Cheng, and Z. Sun, “ Comparison of nasopharyngeal and oropharyngeal swabs for SARS-CoV-2 detection in 353 patients received tests with both specimens simultaneously,“ International Journal of Infectious Diseases, 18-Apr-2020.[Online]. Available: <https://www.ijidonline.com/article/S1201-9712(20)30235-6/fulltext#relatedArticles> . [Accessed 14-Oct-2021]

[2] S. Pondaven-Letourmy, F. Alvin, Y. Boumghit, and F. Simon, “How to perform a nasopharyngeal swab in adults and children in the covid-19 ERA,” European Annals of Otorhinolaryngology, Head and Neck Diseases, 05-Jun-2020. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S187972962030140X>. [Accessed: 14-Oct-2021].

[3] A. Kaufman, R. Brewster, and K. Rajasekaran, “ How to Perform a Nasopharyngeal Swab – An Otolaryngology Perspective, “ Department of Otorhinolaryngology, Head and Neck Surgery, University of Pennsylvania, Perelman School of Medicine, Philadelphia; Stanford University School of Medicine, Stanford University, Stanford, Calif. [Online]. Available: <https://www.amjmed.com/article/S0002-9343(20)30440-X/pdf>. [Accessed: 14-Oct-2021].

[4] A. Koskinen, M. Tolvi, M. Jauhiainen, E. Kekäläinen, A. Laulajainen-Hongisto and S. Lamminmäki, "Complications of COVID-19 Nasopharyngeal Swab Test", 2021. [Online]. Available: <https://jamanetwork.com/journals/jamaotolaryngology/fullarticle/2779393> . [Accessed: 14- Oct- 2021].

[5] H. Lim, J. Lee, K. Son, Y. han, and S. Ko, “A method for optimal depth of the nasopharyngeal temperature probe: the philtrum to tragus distance, ” Korean Journal of Anaesthesiology,28-Mar-2014 [Online]. Available: <https://ekja.org/journal/view.php?doi=10.4097/kjae.2014.66.3.195> .[Accessed 14-Oct-2021].

[6] M. Davids, "5 Ways Robots Perform Mundane Tasks Better Than Humans", Blog.robotiq.com, 2021. [Online]. Available: <https://blog.robotiq.com/5-ways-robots-perform-mundane-tasks-better-than-humans#:~:text=Robots%20are%20more%20precise%20than,something%20robots%20are%20already%20doing> . [Accessed: 14- Oct- 2021].

[7] F. Weichert, D. Bachmann, B. Rudak and D. Fisseler, "Analysis of the Accuracy and Robustness of the Leap Motion Controller", 2021. [Online]. Available: <https://www.mdpi.com/1424-8220/13/5/6380/htm> . [Accessed: 14- Oct- 2021].

[8] J. Wallen, "Engineers develop robots to treat and test Covid-19 patients in a bid to protect health workers", The Telegraph, 2021. [Online]. Available: <https://www.telegraph.co.uk/global-health/science-and-disease/engineers-develop-robots-treat-test-covid-19-patients-bid-protect/> . [Accessed: 14- Oct- 2021].

[9] N. Doremalen, T. Bushmaker, D. Morris, M. Holbrook, A. Gamble, B. Williamson, A. Tamin, J. Harcourt, N. Thornburg, S. Gerber, J. Lloyd-Smith, E. Wit, V. Munster, “Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1,” New England Journal of Medicine, 20-mar-2020.[Online] Available: <https://www.nejm.org/doi/10.1056/NEJMc2004973> . [Accessed 14-Oct-2021].

[10] S. Wang, K. Wang, R. Tang, J. Qiao, H. Liu and Z. -G. Hou, "Design of a Low-Cost Miniature Robot to Assist the COVID-19 Nasopharyngeal Swab Sampling," in IEEE Transactions on Medical Robotics and Bionics, vol. 3, no. 1, pp. 289-293, 1-Feb- 2021. [Online] Available: <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9250573> . [Accessed 14-Oct-2021].