# UP Against COVID - #WorldInnovationDay Hack

19.04.2021

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UP Team
#WorldInnovationDay Hackathon

# Tackling medical resource shortage with ultrasound against COVID-19

## Addressing the UN SDG #3, Good Health and Well-Being

UP Team is a cloud-based intelligence platform provider, which makes augmented sense out of medical images. Our goal for this #WorldInnovationDay Hack is to address one of the **United Nations (UN) Sustainable Development Goal (SDG)** #3[1] Good Health and Well-Being targets, strategically focusing on two targets, namely in:

- Target 3.8 Achieve Universal Health Coverage
- Target 3.D Improve Early Warning Systems for Global Health Risks

By providing a common, open-source **Application Programming Interface (API)** with **Machine Learning / Artificial Intelligence (ML/AI)** capabilities, we propose to cut down the cost for government and health agencies to provide feasibility for low-income patients in poor countries, rural and remote regions of the world, which have "*insufficient health facilities, medical supplies and health care workers for the surge in demand*" (Target 3.8). Subsequently, our platform will leverage existing datasets to implement predictive models that lead to better patient outcomes with appropriate medical follow-up, and to monitor global health (Target 3.D). These datasets will be enriched by the images and knowledge captured by the API itself, leading to **virtuous self-improvement dynamic**. This solution will support the effort to set up **universal health coverage** as well as early global warning systems. Its availability, low-cost and life saving potential makes it a radical game-changer.

In this challenge, we are using the current global pandemic - **COVID-19** and its associated lung damage as a use case.

## Problem statement

The COVID-19 crisis has disrupted the global healthcare system, especially in poor countries with no or limited health coverage. As of today, 138 million people are infected by the COVID-19 virus, and all countries are pooling resources to prevent its further spread. As a result, the UN's 2030 targets to reduce maternal and child mortality, increase coverage of immunization and reduce infectious diseases has been curtailed by limited resources.

Initially, COVID-19 health assessments in clinics involve heavy equipment such as chest **Computed Tomography (CT)** scan, chest x-ray or molecular diagnosis using **reverse transcription-polymerase chain reaction (rRT-PCR)** to analyze respiratory tract specimens with a high false-negative rate.[2] Subsequently, progress has been made. **Lung**

[1] *United Nations (UN) Goals* 3: https://sdgs.un.org/goals/goal3
[2] *European Heart Journal - Cardiovascular Imaging* (2020) 21, 941-948

**Ultrasound (LUS)** imaging the safe, non-invasive, affordable bedside imaging alternative with high diagnostic sensitivity and accuracy, comparable to chest CT scans. Recent studies have shown LUS can be used to reflect the COVID-19 patient infection duration, disease severity, early diagnosis, prediction of outcome for triage and patient treatment.[3]

Nevertheless, the effective use of LUS is prevented by the use of **personal protective equipment** (**PPE**) and adequate protection measures, but most of all by the need for the doctor to learn to realize the medical gesture of capturing an image, and to reliably identify the patterns and information present in the image. For this, the user needs to have undergone complete training and requires their expertise to safely orient the patients to their next healthcare step.

## We help medical staff by providing them quick, safe, accessible and universal AI-augmented diagnostics.

**COVID-19 patients influx often challenges health centers' capacity by increasing the stress on emergency departments (ED) including the medical imaging units and radiologists. To alleviate this pressure, we propose safer alternatives by using a global accessible platform allowing all medical staff to quickly and reliably assess COVID-19 patients disease severity, and monitor patients' lung status for complications using a universal AI-augmented LUS for diagnostics of COVID-19.[4]**

**This solution leverages recent development in software, ML, and medical devices, bringing elements in which feasibility was individually demonstrated, with a setup that is repeatable even in the developing world (Target 3.8). Our open-source platform and standard will also provide added values to post-acute COVID-19 treatment and other applications such as kidney stones, obstetrics and gynecology and deep vein thrombosis (DVT) as a preventative measure (Target 3.D).**

## Different opportunities are aligning

In the last months, there were some attempts to use ML for biomedical COVID-19 image analysis, however these were only on x-ray or CT scan[5]. There is no AI-augmented diagnostics competition at this stage on the market for COVID-19 **Lung Ultrasound (LUS)** assessments.

[3] *Critical Care* (2020) 24:700; *Appl. Sci.* (2021) 11:672; *AJR* (2021) 216:80; *Inten. Care Med* (2021) 47:444;
[4] *Ann. Intensive Care* (2021) 11:6; *Medical Image Analysis* (2021) 69
[5] POCOVID-Net: POCUS https://arxiv.org/pdf/2004.12084.pdf

**Why Ultrasound?**

Ultrasound today is a mature but underutilized technology. It has the potential to upgrade and **replace physicians' stethoscopes**: and it benefits from **portable / point of care hand-held devices (POCUS),** and does not present the same risk of ionizing radiation as x-ray poses. POCUS is an easy to learn portable device that allows quick and repeatable diagnosis, producing consistent results with minimal risk as compared to competitors.

These benefits make ultrasound a **key imaging modality for developing economies** where staff and investment capacities can be limited, and a key tool for the UN SDGs.

**POCUS LUS** in particular shows an increased use in everyday clinical practice - in emergency room and intensive care[6], where portable solutions also minimize the need to move the patient. LUS high sensitivity for the detection of pulmonary involvement allows it to be a **reliable diagnostic and monitoring tool** COVID-19 patients.

Hand-held portable ultrasound device vendors like Clarius[7], ButterflyNetworks[8] or Philips sell handheld devices at a unit level, which can cost from US $3,000 to US $10,000. They focus on sales, not services provided to the customer. We start with **global sub US $1000 devices vendors**, opened under the open-source Pyusbus library[9] and that **support ML/AI solution development**. We then aim at progressively building partnerships with other vendors. Shifting the revenue to the service provided, allowing to **subsidize the device purchase**, making the technology **more affordable and accessible to all**.

These competitors have a strong, historic market presence - however, they are not providing augmented ML/AI diagnostics to their users.

**Why open-source?**

The project will not build open-hardware ultrasound devices, but rather **collaborate with existing device vendors to establish an open-source communication standard**, building on an existing open-source API. It focuses at the moment on the Healson and BMV vendors sub US $1000 devices. Currently, ultrasound images currently depend on closed-source devices that do not allow easy extraction of images for developing ML/AI services[10], which translates in turn to hampered medical and AI research.

OpenSource supports global health solutions by gathering medical staff, developers, manufacturers and communities, to address health problems. In particular, it will:

- provide a common, open-source, cross-vendor device interface standard;
- engaging communities contributions with a common platform;

[6] https://academic.oup.com/ehjcimaging/article/21/9/941/5855021
[7] https://clarius.com/covid-19/
[8] https://www.butterflynetwork.com/covid-19
[9] https://github.com/kelu124/pyusbus/
[10] Existing solutions (eg ThinkSono) have built services with a specific brand, to which they are limited, after months if not years of discussions.

- create a global platform to share and collaborate on large sets of medical images ;
- encourage doctors to share expertise (in a way possibly similar to stackoverflow) while feeding in much required medical images datasets ;
- lower break the sunk costs that each manufacturer need to invest;
- promote the development of open medical standards.

Because global knowledge of global issues is a global concern, the project would be supported by **the POCUS professionals community,** but also by **key technology partners** like Oracle, IBM, Microsoft, with support for open source and proprietary hosting, development or services. Last but not least, priming a platform will **engage medical device vendors** and encourage them to open in turn their devices to access augmented medical decision-making services, and to contribute to them.

**Why ML/AI ?**

The **augmented diagnostics service** we provide is the added-value that stems from the developed open-source standards, and where we generate revenues.
In general, medical doctors must be trained thoroughly to establish reliable diagnostics, using patterns that are hard to discern for the human eye. **Automatic detection is highly relevant as it has been shown to reduce the time doctors need to make a diagnosis.** For COVID-19, the current situation makes medical image interpretation a data problem on a global scale where identification, classification and interpretation must be continuously refined, in a collaborative undertaking. This is precisely where ML and AI operate best, and **provide continuously improved augmented diagnostics** to physicians time after time.

From a wider perspective, the **ML&AI services will improve efficiencies of critical resources** like specialist and medical teams, where the augmented diagnostics will be able to tackle other major global health issues, especially child and maternal health issues.

## The case for a common medical imaging platform

**Global issues require global coordination to tackle them**. Breaking existing silos, and building on the new oil that is data, we offer a unique platform where medical images can be pooled to learn from, and from which new user-pulled services can be developed. The UP platform allows for a medical image collection, sharing and further analysis of different pathologies - at a global scale - radically changing the way medical data is collected and opening new opportunities with a connected thinking between stakeholders' communities.

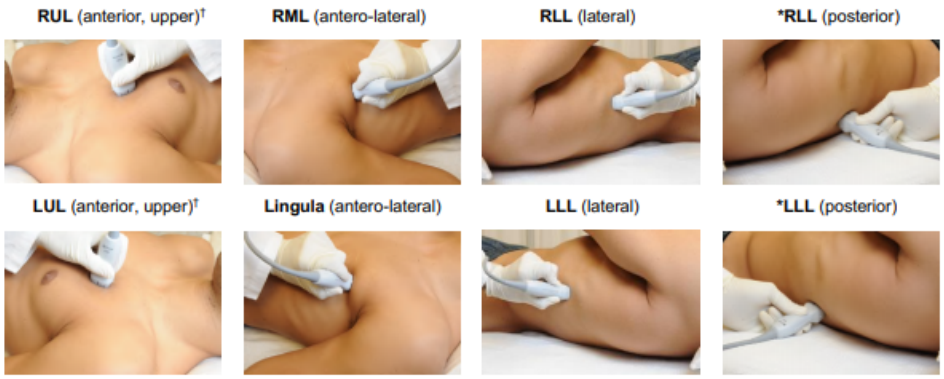
This platform will support clinicians in **rural and developing economies settings** with subsidized devices and augmented capabilities: rural and remote health care practitioners with limited access to specialists will be able to diagnose pneumonia from suspected COVID-19 patients in real time.

# Presentation of the UP Against COVID solution

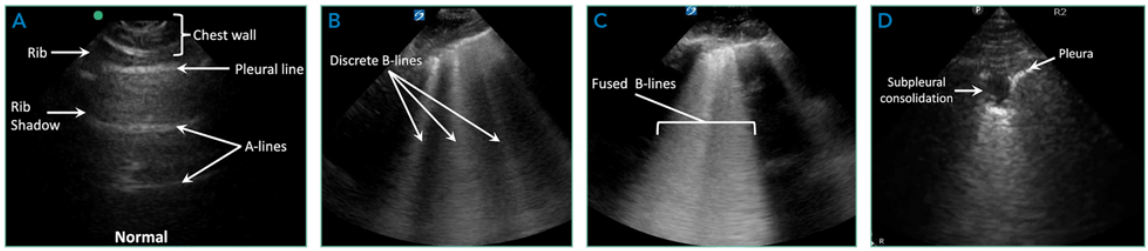
## A three step procedure

Our services are intended for untrained medical staff, to provide support in order to acquire images, and understand them. All in **three simple steps**:

1. First, as an exam consists in taking a series of images, t**he service proposes a medical screening protocol** based on widely recognized steps[11]:




2. Then, **the AI-augmented diagnostics provide commented insights** on understanding the images to identify key indicators of a COVID-19 patient on an ultrasound image, as shown below[12]:




3. The identification of these indicators can then lead to the **classification of the patient case severity and risk**, as well as the **scoring of the patient**. This allows in turn to **complete the medical diagnostic** and to advise the medical staff about **the next steps for the patient.**

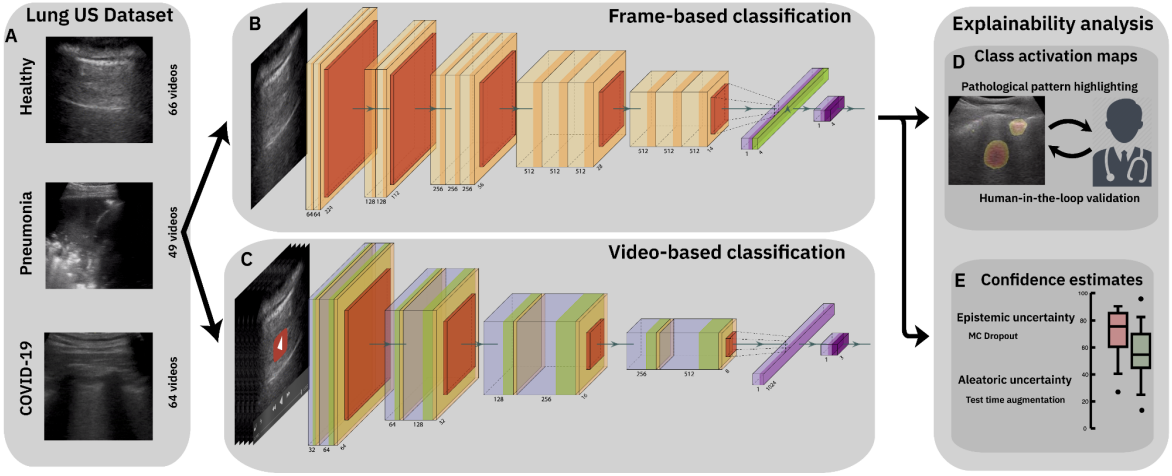
[11] Site ; here
[12] https://cdn.mdedge.com/files/s3fs-public/mathews03340522e_f1.jpg

## How we structure the services

To provide the service, we have built on existing solutions covering backend to frontend, including ML tools (MLflow), data solutions (Airflow), with the support of Oracle solutions. The model is based on a published, efficiency-proven piece of work[13].

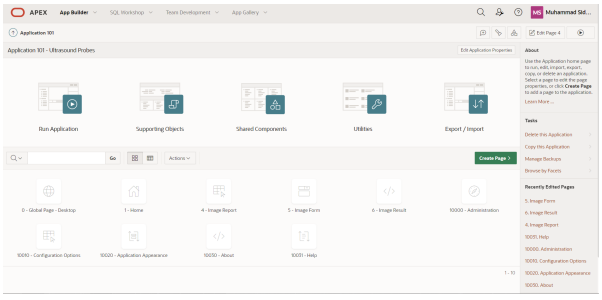
## A bit behind the scenes

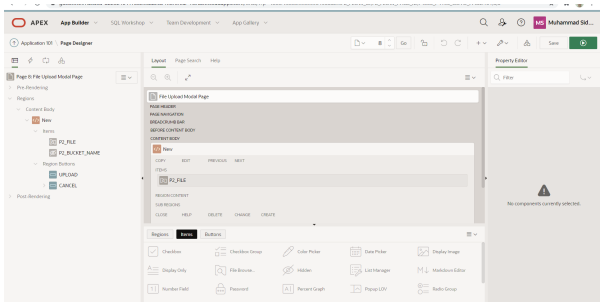
To build on existing solutions instead of reinventing the wheel, we have used the blueprints proposed by "*Accelerating Detection of Lung Pathologies with Explainable Ultrasound Image Analysis*"[14], using ML and AI to support the identification of key ultrasound patterns:




## Oracle

The project was the opportunity to deploy tools in Oracle Cloud. We have created a frontend page using Oracle Apex and worked with the machine learning side with Oracle Dataset.





[13] https://github.com/jannisborn/covid19_ultrasound
[14] https://github.com/jannisborn/covid19_ultrasound

# Building from there - a roadmap

## Business in a nutshell

- **What** : providing AI-augmented medical diagnostic support
- **Savings**: analysis of a patient costs a few cents with a low-cost ultrasound device, compared to the time and resources spent to process a patient for a x-ray.
- **Market**: ~ 20 million users (half of the global health service[15] providers)
- **Feasibility**: this is built on proven technology, with existing proofs of concept
- **Viability & partnerships**: use of the resources is to be paid by the users, but development and infrastructure can be backed by key partners (Oracle, Microsoft, ..) and institutions (WHO, ..) as well as vendors
- **Who pays**: the user - payment per image.
- **Investment requirements**: increasing visibility and scope of the platform

*As an open-source exercise benefitting the commons, the business model would differ from the usual startup*. Still, revenue needs to be created through added-value. However, the UP platform would mostly benefit from partnerships with key players for development, servers, and expertise - including global institutions.

The market for an AI-augmented diagnostic tool would correspond to roughly half of the health service providers, based on **today's penetration of the stethoscope**.

As there are no materials purchases, most of the costs would stem from people and processing powers. This would range to the cost of a few cents, borne by the users. With the help of partners, **the project could subsidize users device acquisition** (similar to the printer and ink cartridges business), especially in constrained settings.

## Revenues

We propose a service subscription. However, for ethical matters coupled with the need to generate income, we would propose different payments,  indexed on:

- **Type of service**: support to decision making and/or cloud storage;
- **Complexity** of the analysis - COVID-19 for example could be cheaper than kidney stones detection or deep vein thrombosis diagnostic
- **Human support** eg to involve a telemedicine expert to check the ML analysis

15 https://www.globalhealthlearning.org/sites/default/files/page-files/Global_Shortage_of_Health_Workers.pdf

- **Country of operation** : fees could be lower for developing countries, backed with support from donors programs like WHO or UNICEF to subsidize the cost and equipment
- **Contributor status**: as an incentive, all users who contribute to the knowledge database by sharing their images would get a discount on their subscription as compensation.

## A point of attention : Intellectual property - IP

Built on an open platform, datasets can be shared with people, but models would remain property of the parties developing them, enabling value capture to encourage sponsors joining the project and invest resources. This would enable a stronger control over the building of these models and eventually their certification for medical use.

The legal status of the models would need to be clarified, as in all ML-related models, as the property of these models could be thought as owned by those who have contributed the underlying data.

## What next? Investment & partnership strategy to boost a development roadmap

The UP core team, formed of the current team members, would form a nucleus to cristallise open-source communities efforts to boost the project use and development. Apart from the existing technology bricks, investment should aim at unlocking the roadmap blocking points, and we would propose to use investment cases for:

**Key R&D investment** to improve the COVID-19 models, and develop new ones for new pathologies, for example in maternal health ;
**Increase penetration** to grow both users and stakeholders communities, by build a pilot in a flagship hospital, unlocking a major manufacturer device and engaging a key infrastructure provider ;
**Supporting medical training** by being accessible to medical educational networks, to help with the correct diagnostics tagging of medical images, strengthening our datasets value.
**Develop global health partnerships** in general:

- Training of medical staff in general using low cost, portable ultrasound devices
- Support to medical researchers to enhancing the current medical protocol to capture images: extra funds would lead to better quality
- Academic researchers: giving images and receiving improved models

In particular, partnerships with manufacturers will be essential in both supporting a cross-vendor hosted solution as well as having buy-in from device producers. As the solution expends, remaining vendors might need to join in to satisfy customers demands getting used to augmented ultrasound imaging.

**End of the submission**

# Appendices (not to be considered as part of the submission)

## Team members

| Name | Key Skill | Email | Role |
|---|---|---|---|
| **Woody H** (frymatic) *GMT-7* | Product, Community, Python, MC. Third Hackathon. | gmail@woodyhooten.com | Presenter/ Media |
| **Eric H** *GMT-4* | Machine Learning, Data Science, Data Engineering, ML Ops, DevOps, programming(Python and R). Some experience in hackathons | eric.hammel.contact@gmail.com | **Team captain** Software |
| **Danielle Alice** *GMT+1* | Signal processing, innovative business models ( Lean, BMC, ExO canvas,) 7th hackathon, but not with the same framework & methodology | thiam.meka.2.goguenheim@gmail.com | Presenter/Media /PM |
| **Luc** *GMT+2* | Hacker, python, ultrasound knowledge Project Manager Bit of business background and product development. Beginner level in hackathons. | kelu124@gmail.com | SME / Business / Hardware |
| **Andrew Gotora** *GMT+2* | Embedded systems, Thingworx IIoT, Azure IoT, .NET (C#), First hackathon | andrewgotora@yahoo.com | IoT, .NET dev |
| **Jan Hapala** *GMT+2* | Python, R, Bioinformatics (genomics), data processing, visualization, machine learning. The first hackathon. | jan@hapala.cz | Software |
| **Danylo Liakhovetskyi** *GMT+3* | Java programming (2 year+ exp.), algorithms, logic-based programs, ability to learn a new language fast. First hackathon. | danylo.liakh@gmail.com | Tech Lead, SWE (back/front) |
| **Muhammad Saad Siddique** *GMT+5* | Languages: java,c#,php,kotlin, Vb,Python(intermediate). 6th hackathon. Quick algo making skill. Also participating in google code jam. Interested to learn dev ops. | Muhammadsaad2387@gmail.com | Front-end |
| **Moneeb** *GMT+5.5* | This my First Hackathon. I'm dealing with the presentation side and beginner in front end and coding skills. | moneebbhatti987@gmail.com | Presenter / Comm |
| **Joe L.** *GMT+8* | Product & process development, agile project management, molecular & cancer cell biology, cGMP equipment validation. First hackathon. | biopharmaprof@gmail.com | PM / SME |

## Mentors

| Name | Key Skill | Email | Role |
|---|---|---|---|
| **Sydney Nurse** *GMT+2* | Thanks Sydney Nurse for your general continuous support and challenges, bringing the necessary step back! He helped us both in the developing and the business sides. He was very helpful! | sydney.nurse@oracle.com | Lead Mentor |
| **Wael Al Masri** *GMT+2* | Cloud Software Engineer, full-stack, Product Developer, SaaS | waelmas01@gmail.com | Lead Mentor |
| **Raouf Hajji, MD** *GMT+3* | Thanks Dr Hajji for your general feedback on medical aspects. | raoufhajji2013@gmail.com | Lead mentor |
| **Lachlan Young** *GMT+10* | Software Developer | Lachlan@tanda.co | Lead Mentor |
| **Gaurav Koradiya** GMT+5.5 | Machine learning | gauravkoradiya@gmail.com | Mentor |
| **Gabriella Marcelja** *GMT+2* | Thanks Gabriella Marcelja for your general feedback on business, legal and marketing aspects. | gabriella.sirius@gmail.com | Lead mentor |

# BONUS !

## Project Resources

[R1] https://www.un.org/sustainabledevelopment/health/

[R2] https://covid19.who.int/

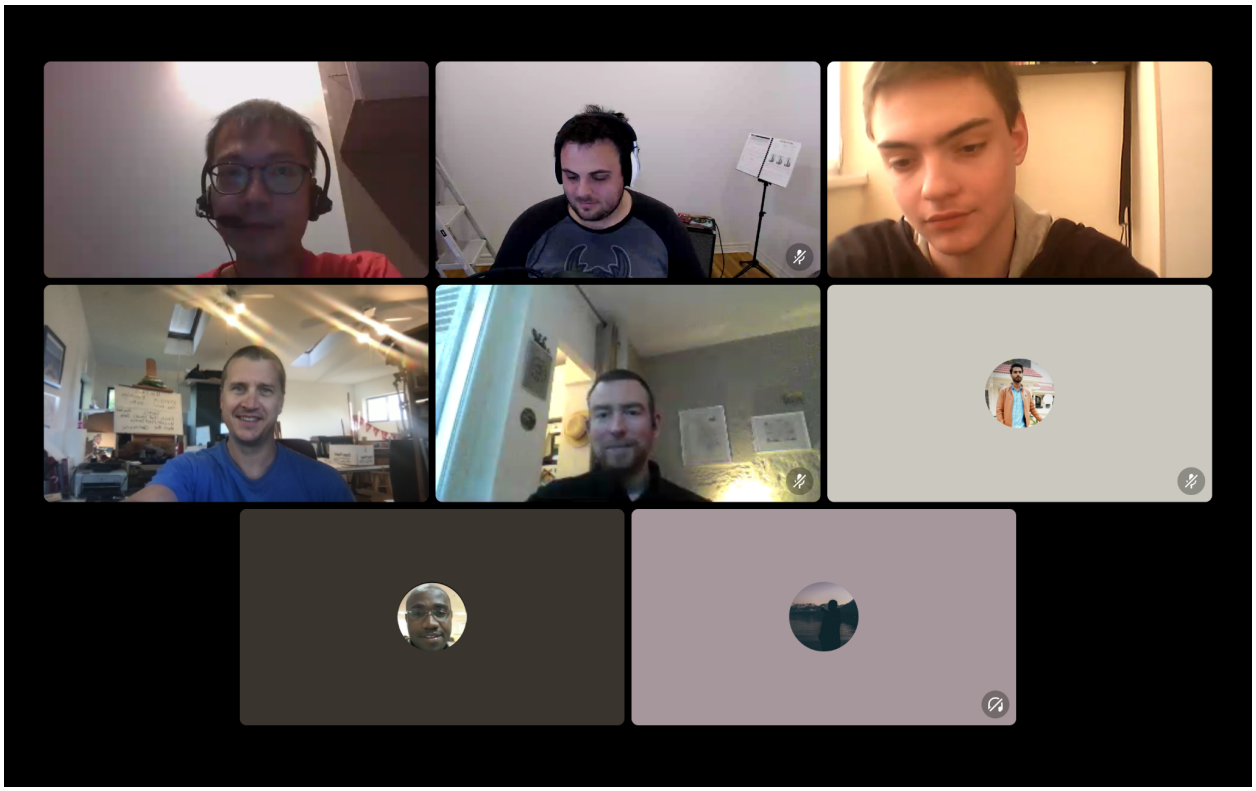
[R3] https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html

[R4] https://github.com/kelu124/pyusbus

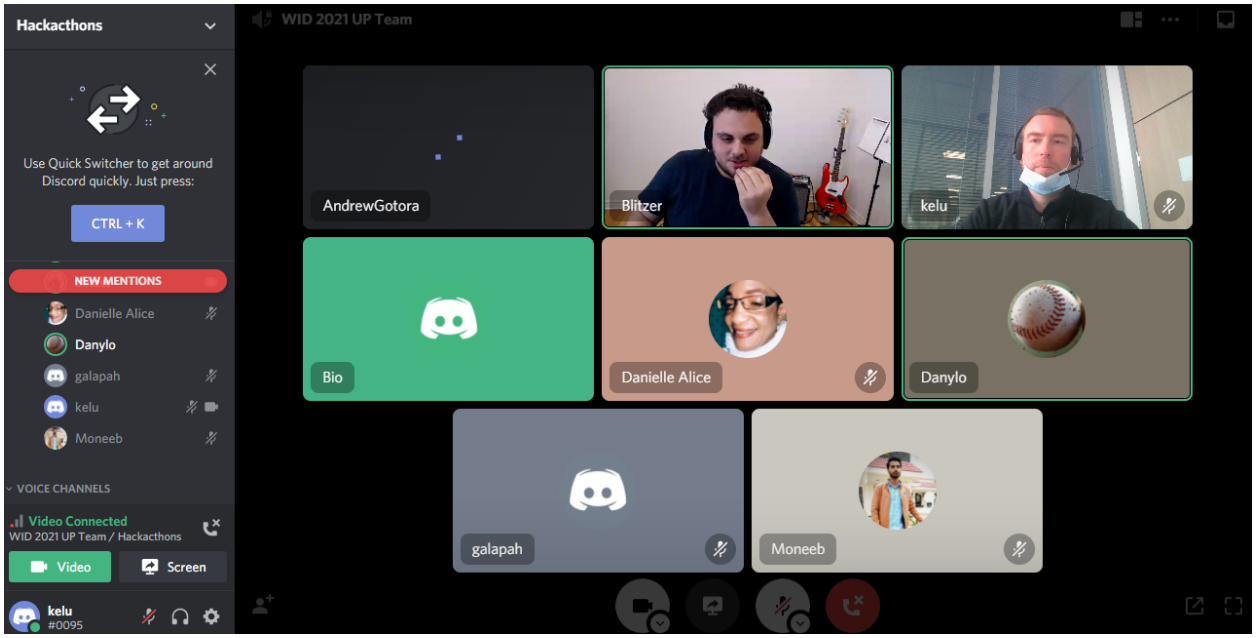
[R5] http://un0rick.cc/goodies/usbprobes

## Team meetings

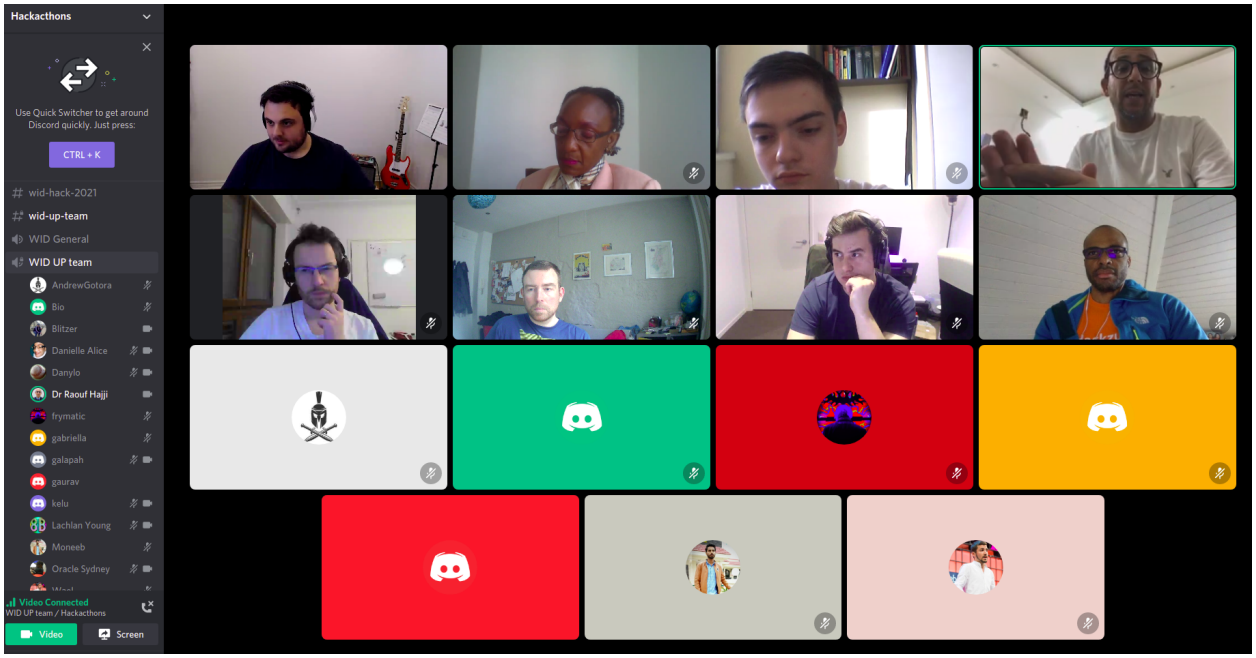
### Initial meeting



## Friday




## Saturday's meeting =)



## Sunday catchup