

THE ONLINE FLYING EDUCATION: VIDEO-CONFERENCING AND DRONES

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Abstract: *The Chinese origin pandemic of Covid-19 was a disaster for the world economy and the entire society during 2020 and at least the first half of 2021. But the pandemic, mixed with the Internet that actually is a given right in all developed societies and communities, also brought huge steps forward in the usage of remote and automated resources for all work environments. Virtually all companies that went successfully through the pandemic appealed to the work-from-home scenarios, in most cases at 100%. Besides standard work environments, the education field had also been forced to move online at an accelerated, some might even say staggering, pace. All over the world, from kindergarten to universities, millions and millions of youngsters moved to learning from online resources. Without the deadly virus originating from China, most of the online learning environments would have remained purely an exercise of small niche usage – being forced by the context, all education institution all over the world deployed (faster or slower) hundreds of versions of online only environments to continue deliver knowledge to their students. Another winner of this unfortunate pandemic context was the field of humanoid robotics and drones. While present for quite a long time already, they are still used only as tech demonstrators only, and are in fact deployed for real-life work environments only on a small scale.*

Keywords: Covid-19 education, drones, robotics.

1. Introduction

The Covid-19 pandemic, the scourge of this decade, was also a catalyst for improving our society's use of advanced tech resources, mostly related to the online video conferences, automated systems, and remote control. Due to the movement restrictions that were enforced almost all over the world, the employees of all categories and from all fields have been forced to rely on remote and automated systems to keep the activity going, at least at a certain acceptable level. A huge advantage for the modern societies was the extension of the Internet in almost every house. This network of networks, the Internet, is now something that we cannot live without, something that has become within the advanced societies as well as emerging ones, a standard utility thought of at the same level as tap water, plumbing, gas, heating, or electricity. The Internet was also considered a right by itself, event since 2010. In 2010, Finland was the first country that actually passed a law that stated the right of their citizens to an Internet connection. The

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piece of legislation stated that all citizens were entitled to a 1Mbps internet connection from July 2010 and to a 100Mbps internet connection starting with 2015 (minimum bandwidth) [1].

The companies that provide us with the internet connections, the ISPs², are nowadays business giants that have at least a relevant role into all layers of our lives: they provide the means to access the Internet, they make sure the connections and communications are maintained at a high quality and reliable level, and they indirectly influence all other services that are based on internet access... which means almost anything and everything today. Even the non-commercial activities, the charities and most notable CSR campaigns are also based mostly on internet (through social-media mostly) for reaching their goals [2].

The Internet and its ubiquitous presence made it possible for the human society to cope with the pandemic from a far. Educators all over the world deployed different online platforms in order to keep in touch with their students and continue deliver knowledge and support even from a remote location. The huge advantage of the broadband Internet connections (both classic cables, optical fibers or even mobile 4G data – 5G is still too emerging a technology to be taken into account on a larger scale) is that they can deliver excellent quality video conferences. Even though, clearly, it is not exactly the same as a face-to-face meeting, the live-online meetings are the next best thing. Moreover, in some scenarios, the live-online meetings are even a superior choice over the standard class meeting. We can just think of the case of master students, having classes from 4:30 PM, on daily bases. In vast majority, the master students are also employed during their studies and as a consequence, in a normal environment, they should run from their jobs to the campus in order to make it to the start of the classes. In a crowded city, trying to get somewhere around 4:30 PM is a huge challenge, as one might lose a lot of time in traffic. This would be one of the scenarios in which the live-online meeting for the delivery of the class content would be beneficial for all actors involved.

Also, under the constraints of the pandemic, the drones have also received a boost in usage with more and more entities thinking of using them on large scale for deliveries, instead of the classic and restrictive scenarios of aerial photography and emergency support. And we leave alone here the military scenarios, which proved drones to be highly effective both on results and costs points of view – lastly during the Armenia vs. Azerbaijan & Turkey conflict in 2020. Azerbaijan's Turkish design (and maybe even controlled if we are to believe some of the media news) military drones, especially Bayraktar TB2, have made short work of soviet and Russian equipment used by the Armenian forces [3].

And last, but not least, the humanoid and not so humanoid robots (but NOT industrial robots – a different category) were also on the upper side of the pandemic. If humanoid form robots are still hardly finding any real-life scenario in

² ISP = internet service provider

which they might actually bring a decisive advantage, the more specialized non-humanoid form ones have made a difference in medically challenging environments. Medical robots with UV setups have become something almost usual for sterilizing entire areas and making sure viruses are not alive anymore.

2. Live online education

Almost all countries have resorted to using live online education during 2020 and 2021. We shall present here the steps taken by several different countries, from different geographical areas – several countries with reputed education systems and the countries which are direct neighbors to Romania.

In Europe, close to Romania, Austria has deployed an extensive set of measures to ensure a successful online education system. The Austrian Ministry of Education has developed and offered an online educational platform called Edutech³, with learning and exercising content from third party providers accepted by the Ministry. The content ranged from kindergarten to high-school. Another complementary measure was the offering of a dedicated TV educational program for all school levels pupils, through the national public station ORF-1.

Finland, a country with one of the most highly thought educational systems, has deployed a broader array of tools. Even in normal situations, the country is constantly using e-learning environments on a larger-scale (due to the natural conditions and other factors) – and as a direct consequence, they have an extend experience with such systems. Finland’s public entity that supervises this sector is the National Agency for Education. They organize and supervise an entire network of solutions form electronic delivery of knowledge to students, based on different technical solutions: Microsoft365, Google Classroom, Moodle, Zoom, AdobeConnect, Ville or even the older Skype. They also make extensive use of gamification, with simulators and education gaming based on DigiVertu⁴, Sandbox⁵ or VirtualAutoedu⁶. Capitalizing on their already extensive experience with e-learning environments, the Finish educators can also take advantage of other established tools and repositories:

- Content Repository and Materials⁷ – maintained by the National Agency for Education.
- Library of Open Education Resources – maintained jointly by the Ministry of Education and the National Agency for Education.
- Finna – developed under the auspices and with funding from the Ministry of Education as a component of the larger project: National Digital

³ <https://eduthek.at/schulmaterialien>

⁴ https://www.tts.fi/tutkimus_ja_kehitys/tutkimushankkeet/paattyneet/digivirtu/aineistot

⁵ <https://www.salpaus.fi/>

⁶ <https://www.lumousinteractive.com/lumous-interactive/virtualautoedu/>

⁷ <https://www.oph.fi/en>

Library. It provides open access to electronic materials from museums, libraries, public and private archives throughout the country.

- Yleisradio⁸ - providing free learning resources and programs through the national broadcasting company of Finland.

Our southern neighbors, Bulgaria, launched in March 2020 an integrated online learning platform through the Ministry of Education. The platform presents textbooks for the pupils of the first to the tenth grade and most higher education institutions have implemented their own individual platforms, with an approximation of around 90% of the students using e-learning systems. The Ministry of Education also created and made available an e-content repository, called the National Electronic Library for Teachers, with content in various forms (written, video, quizzes, exercises, methodologies etc.). The schools in Bulgaria have deployed the Microsoft Teams platform for their only knowledge delivery platform, with the Ministry of Education providing a centralized helpdesk and support entity.

Our brotherly neighbors from the East, speaking Romanian but snatched from their country by the aggressive Russian presence in the area (the Tsaristic Russia, the USSR or Russian Federation in different times) - the Republic of Moldova, have also managed to mount a decent answer to the Covid-19 pandemic. Different educational institutions in Republic of Moldova use the Studii.md portal in order to connect their students, the faculty and even the parents to the online e-learning education system. The portal was developed with the support provided by the United Nations Development Program. The online platform is able to provide different capabilities, such as: registration, calendar, scheduler, analytics tools, library and student info. Around 32000 users were already registered on the platform in 2020 (students, faculty, and parents).

Ukraine, already hit and weakened by Russia's theft of Crimea and the Russian backed insurgency in the East of the country, has managed only a less substantial response to the educational crises. The only centralized content delivery system for education resources was based mostly on the broadcasts from Ukraine TV. The "All Ukrainian School Online" platform is also extensively presenting the schedule of the TV broadcasts and has fewer other resources. The recordings of the live TV educational shows are also archived online on the platform and make up the bulk of its content.

Serbia has answered the pandemic, from the educational point of view, in a centralized manner. The Ministry of Education started by broadcasting educational content programs for pupils, through the Serbian Radio Television. As Serbia is still trailing in Internet availability all over the country, the Ministry instructed the schools to publish the plans and schedules of the publicly available radio and TV

⁸ <https://yle.fi/aihe/oppiminen>

programs in places directly available without the need to access the internet: school entrances, notice boards, messaging systems, and other public places. The Ministry of Education also developed the MySchool e-learning platform at national level, which has a broad repository of e-learning content, including the recordings of the radio-tv programs. The Serbian authorities also developed and provided guidelines for different scenarios of communications between students and faculty, based on technologies such as Microsoft Teams, Zoom or Viber [4].

In Romania, the Ministry of Education already had a quite extensive set of e-learning materials, comprising actually all the manuals for all elementary, primary and high schools⁹. In the same time, the National TV (TVR) was also broadcasting specialized programs with educational content, classified for different grades.

The main challenge of Romanian educators was to provide an environment to deploy live-online video classes, as 99% of Romanian educational institutions did not even try such methods before the pandemic. The Ministry of Education, and the local authorities in several cases – like the Bucharest 1st district Town Hall for example, launched projects to buy and distribute huge numbers of electronic devices – tablets. The idea, good in essence, was actually a waste of money in quite a lot of cases. The Bucharest 1st District Town Hall rushed to buy tablets and 2 years online data plans for them, managing to deliver them well before the Ministry even started to deliver in other parts of the country. Nevertheless, another good idea was in fact detoured into a bad result. The rush was actually possible because the then-mayor was during a re-election campaign (which fortunately he lost), the price paid for one no-name medium-capabilities tablet was way too high and the vast majority of the pupils in the area (one of the best developed and wealthy in the entire country) were actually in no urgent need of those devices. Meanwhile, for several months, the schools were not able to organize and deliver online classes not because of the lack of hardware but mostly because poor organization, poor IT skills of most faculty and their disinterest in the matter. The Ministry of Education offered all educational institutions below the higher education level (which has its own autonomy) the possibility to use reputed online platforms, like Google Classroom or Microsoft365, for free. As soon as the lower-level organizations (mostly at school level) actually learnt a minimum of usage details they started to deliver e-learning content over Google Classroom. Most of the Romanian schools chose it because of its easier setup and commodity of use, even though Microsoft365 Teams offered at least the same features and several more advanced security ones, but which require specialized personnel not widely available. After the first month of lockdown in Romania, at least in the urban areas, only the teachers that did not want to deliver live-online classes were actually not delivering them. The main enemy of the e-learning systems were the teachers (again, in the urban areas where the infrastructure was not a real problem) – some because of their inability to use electronic devices/resource, and some only because they did not want to.

⁹ <https://www.manuale.edu.ro/>

There were lots of cases even in Bucharest, even in very central schools, when teachers refused to deliver live-online classes even though they had all the needed tools and materials to do it. Within a survey conducted by the Romanian Council of Pupils, linked to the 2019-2020 live-online classes, there were around 12000 answers. Out of those, only 11% were from pupils in rural areas (see Figure 1) and only 63,70% of the respondents said that their schools used e-learning methods (see Figure 2)!

Din ce mediu face parte școala ta?



Figure 1. Where is your school situated? Rural areas (blue section) – Urban areas (violet section)¹⁰

În unitatea de învățământ în care ești școlarizat se practică metode de predare și evaluare virtuale?

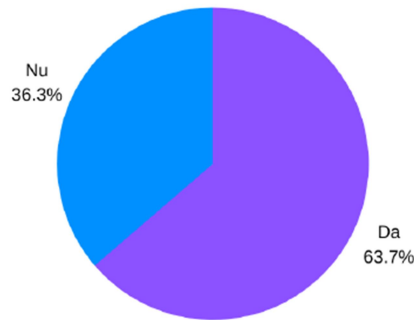


Figure 2. Does your school employs e-learning and e-evaluation? No (blue sections) – Yes (violet section)¹¹

Moving forward, to the higher education system, Romania finally delivered a great answer to the problem. Opposite to the elementary/primary/high schools, the

¹⁰ <https://consiliulelevilor.ro/wp-content/uploads/2020/04/Raport-privind-accesul-elevilor-la-educa%C8%9Bie-%C3%AEn-mediul-online.pdf>

¹¹ <https://consiliulelevilor.ro/wp-content/uploads/2020/04/Raport-privind-accesul-elevilor-la-educa%C8%9Bie-%C3%AEn-mediul-online.pdf>

universities already had different online platforms for different services, including online e-learning resources (even though only in asynchronous mode generally). The Romanian-American University in Bucharest, for example, managed to finalize and launch a fully secure and complete live-online system, based on Microsoft365 Teams and the accompanying Microsoft365 service, in around one week of exhausting work. When RAU started the live-online meetings everything went exactly as in the standard time-table, with the exact same schedule – the only difference was that students jumped from a team to another instead of going from one lecture room to another □. The results of the 2019-2020 and the 2020-2021 academic years, from the point of view of the knowledge delivery to the students, were very successful. The only issue, that is still problematic everywhere, is the evaluation system. While the delivery of content through the e-learning systems, both synchronous and asynchronous, are at quite high levels, the evaluation procedures are far from the levels of the face-to-face ones.

With the pandemic (hopefully) gone, or on the verge of going away, the Romanian educational system must seriously think of implementing at least hybrid methods of content delivery. A minimum of IT skills from the teaching staff would have saved countless lost hours for the pupils and students. All those skills, like any others, must be constantly used in order to not become obsolete and forgotten. A hybrid learning system, or maybe even fully online knowledge delivery systems in some cases, coupled with face-to-face evaluation processes are probably the best way the education can follow for the near future.

3. The Covid-19 push for drones

One of the (quite many!) technical sub-areas pushed forward by the pandemic was also the drone usage. The current drones are already used for several years now in precise and somewhat niche areas, such as emergency systems, aerial photography or remote surveillance (foto or through other sensors) [5].

Even though in most countries their legal status is still under development, the drones are more and more sought out for other tasks that they might be suitable for, with several technical tweaks maybe. The drone delivery systems are already tested and envisaged by the biggest players in retail, with some of the best-known names already displaying very well-advanced prototypes and programs.

Amazon is already advertising its future PrimeAir service, while still in development stage¹² (Figure 3).

¹² <https://www.amazon.com/Amazon-Prime-Air/b?ie=UTF8&node=8037720011>



Figure 3. Amazon real delivery drone – PrimeAir service trials¹³

Another delivery company, the multi-national UPS, is also constantly showing its advances in the field:



Figure 4. UPS Real drone delivery flight¹⁴

¹³ <https://www.amazon.com/Amazon-Prime-Air/b?ie=UTF8&node=8037720011>

¹⁴ <https://www.ups.com/us/en/services/shipping-services/flight-forward-drones.page>

But, in order to find more and more real-life scenarios uses for the drones we have to democratize access to them. During the last years, the prices for such devices plummeted, with some drones available even for less than 100 dollars on some online retail e-shops.

Nevertheless, the least expensive options are not always the best – as there is an electronic device which has a certain degree of complexity, the inexpensive drones are usually missing different features or have a very limited life-span (battery and over-all construction included here). Out of the quite extensive offer available today for educational drones I consider the Ryze Robotics DJI Tello Edu to be one of the best options.

While there are at least 6 other educational drones quite similar to the Tello – Sky Viper e1700, Robolink CoDrone, Parrot Mambo, Makeblock Airblock, Dronea Aviation PlutoX – the result of the Ryze Robotics and giant drone-manufacturer DJI is still the most complete and feature-packed solution, for this price-range. The Tello Edu is now available for around 100-150 euro online and it present a more than decent specs sheet:

- 720P HD video streaming
- 5MP photo
- ~13 minutes flight time
- Mission pads
- Scratch/Python/Swift Programmable
- Dedicated SDK
- Swarm control through programming



Figure 5. DJI Tello in flight¹⁵

¹⁵ <https://www.ryzerobotics.com/tello-edu/videos>

The most important advantage of Tello over the other similar drones is its ability to be programming-controlled at both individual level as well as in a group (swarm) of more similar devices. Moreover, the SDK of the Tello gives the educators and the students the possibility to further their projects from simple programmed flight-paths to more complex process, such as image recognition.

For example, one can use the public OpenCV library for implementing a face recognition and tracking system onboard such a Tello drone. I will exemplify the easiness of connecting and working with the Tello video feed through the Gobot framework, a programming framework realized in Go as programming language and dedicated to the IoT and robotics. The framework puts together drivers for a large number of devices based on Raspberry Pi or Arduino, for different drones and other RC devices¹⁶.

In order to just capture the video stream from the Tello education drone and show it live on our PC screen we just have to make sure that OpenCV is installed on the PC and also the video decoder-encoder ffmpeg is present.

We then have to make sure, in the Gobot code, that we have imported all the required elements:

```
package main
import (
    "fmt"
    "io"
    "os/exec"
    "time"
    "gobot.io/x/gobot"
    "gobot.io/x/gobot/platforms/dji/tello"
    "gobot.io/x/gobot/platforms/opencv"
    "gocv.io/x/gocv"
)
```

Especially the */dji/tello* and the */platforms/opencv* command must be present.

We also have to set the size of the video shown on the PC, as in the code below:

```
const (
    frameSize = 960 * 720 * 3
)
```

¹⁶ <https://gobot.io/>

The main function of the code, quite similar to the C++ approach, is described by the *func* key word and the *main()* identifier.

```
func main() {
    drone := tello.NewDriver("8890")
    window := opencv.NewWindowDriver()
    work := func() {
        ffmpeg := exec.Command("ffmpeg", "-i", "pipe:0", "-pix_fmt",
            "bgr24",
            "-vcodec", "rawvideo", "-an", "-sn", "-s", "960x720", "-f",
            "rawvideo",
            "pipe:1")
        ffmpegIn, := ffmpeg.StdinPipe()
        ffmpegOut, := ffmpeg.StdoutPipe()
        if err := ffmpeg.Start(); err != nil {
            fmt.Println(err)
            return
        }
    }
}
```

Inside the main function we define the drone variable by opening the Tello driver already present inside the Gobot framework, as well as the new window which will show the video through the OpenCV driver inside the framework.

The actual function which brings the video into our already designated window is presented below:

```
go func() {
    for {
        buf := make([]byte, frameSize)
        if _, err := io.ReadFull(ffmpegOut, buf); err != nil {
            fmt.Println(err)
            continue
        }
        img := gocv.NewMatFromBytes(720, 960,
            gocv.MatTypeCV8UC3, buf)
        if img.Empty() {
            continue
        }
        window.ShowImage(img)
        window.WaitKey(1)
    }
}()
drone.On(tello.ConnectedEvent, func(data interface{}) {
    fmt.Println("Connected")
})
```

```
        drone.StartVideo()
        drone.SetExposure(1)
        drone.SetVideoEncoderRate(4)
        gobot.Every(100*time.Millisecond, func() {
            drone.StartVideo()
        })
    })
    drone.On(tello.VideoFrameEvent, func(data interface{}) {
        pkt := data.([]byte)
        if _, err := ffmpegIn.Write(pkt); err != nil {
            fmt.Println(err)
        }
    })
}
robot := gobot.NewRobot("tello",
    []gobot.Connection{},
    []gobot.Device{drone, window},
    work,
)
robot.Start()
}
```

Going forward, there is not too difficult a task to start processing the live video feed coming from the Tello drone in order to check for certain images (face/object recognition training). By using OpenCV also, in conjunction with any compatible programming language, such as C++, Java or Python, we can look for a certain image inside the video stream and then, using it as a trigger, start sending different commands to either the drone or to another linked device. There is an easy and far from perfect surveillance system, but nevertheless it can be a very good start for any student that wants to see a fast implement of a real-usage scenario.

For an even more complex scenario, which I will further develop in a future paper, the video stream that comes from the Tello drone (which is able now to follow a speaker for example) can be fed further to a video conferencing system (Teams, Zoom, Skype etc.) and thus having a live participant to a video conference delivering its presence through an educational drone, from an outdoor location and in movement.

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