S02E05: The Quest for Sustainable Food Ecosystems

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Kyle Fox (00:26):

This is the Smarter World Podcast, focusing on breakthrough technologies that make our connected world better, safer, and more secure. I'm host Kyle Fox. Each episode, we introduce bright minds and their approach to a more sustainable world. We discuss the opportunities and challenges they face, and how technology can change the world for the better. Today's episode is all about drones, and how they can help achieve sustainable food ecosystems.

(00:51):

I'm joined by Dan, the winner of our latest HoverGames challenge: Land, Sky, Food Supply. For those of you who are not familiar with the HoverGames and the most recent challenge, I recommend you check out our episode from last October. Past HoverGames challenges have addressed other issues facing society, like disaster management and health crises. Dan is the winner of our third annual HoverGames competition, which challenged participants to innovate ways to use drones and rovers to help achieve a more sustainable food ecosystem. The competition offered drone development support to coders, developers and innovators, to use in exploring software and hardware solutions for achieving sustainable food ecosystems in the future. Dan, welcome to the pod.

Dan Marius Dobrea (01:37):

Hi, Kyle.

Kyle Fox (01:38):

Welcome, it's so great to talk to you today. First of all, congratulations on winning the HoverGames. There were over 400 entrants, and your solution was chosen, and we're going to talk all about that today.

(01:49):

I've personally read through how you built your drone, fantastic writeup by the way, very detailed, and we'll get to that shortly. First, can you tell us a little bit about yourself? For instance, where are you from, and what are you doing when you're not building drone solutions?

Dan Marius Dobrea (02:03):

I'm from Romania, and I'm professor at the Gheorghe Asachi Technical University of Iaşi, Faculty of Electronics, Telecommunication and Information Technology. For me, electronics and information technology is my passion and my hobby, so in my spare time I develop different cool application and systems alone or with my friends, colleagues, or students to help others to learn and of course to have fun. If you want to know more about applications or system developed, please check my YouTube channel - *i3Drones & iTech for Life*.

Kyle Fox (02:37):

And I have personally checked that out and you have hours of videos there. It's a fantastic resource for our listeners to go check out. So let's start unpacking this a little bit. The opportunities for smart technology to make farming more sustainable really seem to be as immense to me as its complexity and our impact in our lives. So you were able to build a drone that addresses this and help farmers specifically helping to detect grapevine diseases. Can you elaborate on this because I'm assuming vine diseases aren't something I'm guessing our listeners know much about.

Dan Marius Dobrea (03:10):

My idea is that all type of crops have different diseases. For example, these diseases are manifested through the structure, shape, color of the leaves. Therefore, although my system was developed to identify the vine diseases, it can be used to determine the health status of other crops in a similar way. There are a large number of diseases. In my project, I focused on two of them with a very important impact on the vine. The first one is generated by a mite species that infect grape leaves. The second one is a grape wine viral diseases. Currently, there are no way to cure this virus diseases. Now to give you some numbers, many estimates of the economic cost of the vine exist. For the second diseases, several losses estimate range from $25,000 to around $227,000 per hectare.

Kyle Fox (04:07):

Yeah, that is a significant number.

Dan Marius Dobrea (04:09):

Yes. Other estimate consider a revenue decline of up to 77%. As a direct conclusion, this intelligence system or other similar systems are essential because a timely diagnostic and accurate identification of disease are decisive for controlling disease spread and assuring healthy development. Moreover, the early detection of the diseases will determine the use of pesticide only when necessary with a positive impact on the environment.

Kyle Fox (04:41):

So the ability to come in and treat the vines in a way that is only focused when they need it as opposed to widespread pesticide use, which is going to have a positive impact on the environment.

Dan Marius Dobrea (04:52):

Of course.

Kyle Fox (04:53):

The picture of my head is that this is going to be a visual approach. You're going to have a drone that can look at a vine and decide through some techniques whether or not this vine has a problem and especially if it's not a curable disease, give somebody an indication they need to remove this vine before it spreads. So maybe we can talk a little bit more about your overall approach. I'm assuming you started first with researching on what these different diseases might look like to be able to train your neural nets in your drone to recognize them. So can you walk me through what are those next steps that you did to get that drone up and flying?

Dan Marius Dobrea (05:29):

The main idea was to teach an intelligence system based an artificial neural network. This is an neural network similar with the one from our brain to distinguish between different types of leaves. It's like teaching a small child. The texture of this leaf is that of a diseased leaf attacked by mites. This leaf is healthy and this leaf has a viral disease. This process was repeated 10 of thousands of times. Eventually the intelligence system based on the video images of the leaves was able to differentiate between different type of diseases. Next step, right now the drone is able based on the PX4 Autopilot to fly on a predetermined path. The next step will be to use the onboard camera and to estimate the position and the altitude dynamically and to move in this way autonomously through the vineyard.

Kyle Fox (06:22):

Fantastic. What kind of accuracy rates are you seeing on your trained neural nets after you got them trained?

Dan Marius Dobrea (06:28):

I obtained around 80% of the accurate identification, but I use a small database, not very small. It was around 300 images and in each images I have 1, 2, 3, or maybe more leaves and I am sure that these performances can be increased very easy.

Kyle Fox (06:49):

When I think about the size of vineyards, being able to have an 80% rate versus sending humans down the vine rows row by row is going to be very efficient to be able to use the machine to do that work for us. In expanding upon that, you leverage the HoverGames developer kit, and I understand you added components like a LiDAR.

Dan Marius Dobrea (07:09):

Yes.

Kyle Fox (07:10):

Depth cameras to it, et cetera, because we just talked about neural nets, but now it's also about getting the information into the drone to actually make the decision, make the inference. Maybe expand upon that. Which hardware part helped you the most and what were some of the challenges you encountered?

Dan Marius Dobrea (07:26):

The most important component was i.MX 8M Plus development part produced by NXP now under the name of NavQPlus. This is a small but powerful Linux computer with a neural processing unit able to run the deep neural network on it and also to run the robotic operating system on the arm processing units. In short, this system was the brain of the robotic drone system developed. Without the NavQPlus, the system would have been only a concept proof system. Based on this development system and mainly based on the neural processing unit, it became a realtime identification system, a complete solution.

Kyle Fox (08:05):

It also sounds like you needed the processing power to be able to run your neural nets, pull in the data, but you also had to balance flight time. When I think about a very large vineyard, you're going to need to have as much loft time as possible. Did battery life and battery size come into play here?

Dan Marius Dobrea (08:21):

Yes. With my system that was developed, I have around 10, 11 minutes of flight, but the system can be easily improved mainly because you must choose the right motors, the right propellers, and from my experience with other type of drones, you can easily increase this flight time. But in this competition, I do not have enough time to improve this and this will be done in the future certainly.

Kyle Fox (08:51):

Makes sense. In fact, some of the videos that you've created, I've seen you've done analyses on various types of propeller designs to be able to increase loft time, decrease noise, et cetera, which seems like that would come into play here. We've talked about neural nets and the actual hardware. What was really interesting to me is that while you were developing this drone, I noticed that you actually did some work to help make that hover drone more robust. It sounds like you encountered some EMI issues. Was that actually one of your most difficult challenges or were there some other general challenges that you needed to tackle that you can talk to us about?

Dan Marius Dobrea (09:26):

In my previous competitions, the electromagnetic interference was a big problem. To give an example, I lost one of my drones in a wooded area. But one of my goals of this competition was to solve this problem in order to be able to flight without any kind of problems, but in order to develop this kind of application, several cutting edge technology need to work together. Technologies as robotic operating system, machine learning, neural processing unit PX4 Autopilot, MAVLink, Linux operating system or stereo deep sensing. Therefore, the main challenge was to have a deep understanding of all of this technology in order to develop my system and to put to work together without any problems.

Kyle Fox (10:10):

It does sound like there's so many things that meet just to be able to create this solution. We've talked about hardware, software, training neural nets, understanding the science, the vine diseases themselves, taking action on it. It's quite a complex problem that you've developed a solution for. I'm going to take us in a different direction a little bit. We've talked a lot about the solution and this is just out of curiosity for me. I come from a farming family and I know from experience there's a lot of potential crops that could benefit from your approach. Did you know at the beginning you wanted to invent a solution for vineyards or did you also have other ideas and if so, what were they?

Dan Marius Dobrea (10:52):

From the beginning, I aim to develop a dedicated system for the vineyard. The initial proposed solution was composed of two components. The first one was based on an intelligent adaptive directional spraying of pesticide. The second one was a system presented previously to detect diseases through the leaves. This competition includes a significant research component, but the research to develop an innovative product may or maybe not succeed. So I propose these two components to have a little space and to have a backup solution. The second system was fully implemented while the first one was only developed around, I don't know, let's say 30% due to several technical difficulties. If you allow me little advice for the future competitors. In this competition, the basic idea is that you have to be flexible and to be able to choose the

solution, the path where you get the best result within the existing constraint, the hardest one being the available time.

Kyle Fox (11:54):

That makes complete sense. Advice being when we're going for it, try to come up with a solution that you can prototype because in essence, you're plowing the road for other people to follow in your footsteps, and what I'm hearing from you is there's a lot of potential here and you can solve a time problem by putting more resources and development resources, money into this approach to be able to get the same benefit. That's really interesting because farming is notoriously complex, widespread, and we are highly dependent upon it, so making it more sustainable isn't just the right thing to do. It's really necessary for our survival providing food for the planet. In talking about this applicability to grape vines, what are some of the other potential opportunities? You talked about pesticides, that really piqued my interest in being able to perhaps reduce our reliance on pesticides, being able to identify diseases earlier and taking corrective action. So what are the other potential opportunities do you see this technology playing in sustainable farming? Are you for instance, personally hoping to continue innovating on the farm?

Dan Marius Dobrea (13:05):

If we speak about the technology development from years ago, the technology was able to develop by itself. Right now it is not in this direction. You must use different parts of different concept for different domains in order to build an application. For example, the IT technology plays a vital role in the development. Everything, for example, from medicine to agriculture, but with one note. IT technology must be made for people based on the moral and ethical consideration. I can give you many examples of potential solution in agriculture, but I challenge all the listeners to read the great solution proposed for this year's HoverGames competition and they will have a much more complete and accurate picture that anything I can say right now. As for your last question, the answer is yes. I want to apply for a national competition for research projects in my country to complete the whole system as I originally designed.

Kyle Fox (14:09):

Dan, this has been a fantastic discussion. I'm so excited about the technology that you've pioneered and your clear willingness and spirit to want to take it to the next level and I'm looking forward to seeing what you and the people that follow you are able to create. Before we close though, we always ask this question. Through your eyes, I'd like to understand how do you envision a greener world 50 years from now? What does that world look like to you?

Dan Marius Dobrea (14:36):

It isn’t easy to say this. In 50 years, I envision a world where sustainability and environmental protection will be top priorities. I see the use of renewable energy source like solar, wind, hydropower and other form of energy unknown or inefficient right now. Maybe energy will be extracted from the solar wind, the cost of such energy will be cheaper and even I wish that this energy to be free in order to support an equal development of all countries. From the agriculture point of view, maybe the agriculture will be more sustainable. Farmers will shift toward sustainable farming practices that will reduce the use of harmful pesticides and fertilizers and they will prioritize soil health and biodiversity. For example, in principle, there will be a return to the agriculture made by our ancestors, a natural one, but based on and supported by all the existing technology at that time, integrated and compatible with the nature and the people of that time.

Kyle Fox (15:46):

I love that vision and I love what you said there. We want to go back into the past to be able to ensure our future is the way I would describe what you just said and the idea of energy being low cost to free to make it equitable so that everybody can benefit from it. I look forward to the world that you see and I hope that we all can journey toward that. Dan, it has been an absolute delight talking with you. Keep doing what you're doing. You're out there doing something wonderful and I hope our listeners have gotten some great insight on this and I highly recommend that you go look at the HoverGames competition and the results that Dan put together as well as his own videos about drones and all technologies associated with them. Thanks for listening and we will be back soon with another episode.