

Croptimize: A Novel Robot to End Agricultural Yield Inefficiencies Through Crop Switching

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Abstract

Problem Statement/Purpose:

Currently, many farmers plant crops that have grown well on their land for generations. However, climate change is starting to cause sizable decreases in crop yields. Meaning, crops native to certain areas which previously flourished are now becoming less compatible to their environment. MIT professor, Arnaud Costinot, found that roughly 66% of crop yield issues can be fixed by relocating farms or crop-switching.

The purpose of Croptimize is to allow farmers to determine the most optimal crop to grow on a certain plot of land and adapt to climate change's negative effects on yields. It utilizes a mobile robot unit, a kNN machine-learning algorithm, and environmental data to suggest the best crop(s) to grow in a certain region.

Methods:

First, several data points regarding optimal conditions for growing several crops around the world were collected and put into a CSV database. Next, we assembled the robot. We gathered several sensors to test environmental conditions (soil pH, humidity, above-soil temperature, sunlight intensity, and NPK nutrient concentration). We connected these sensors to an Arduino Mega using various breakout boards, which interprets the sensor data it collects and sends it to a Raspberry Pi through a serial connection. The Raspberry Pi uses the collected data to run the ML algorithm and outputs results to a database. We organized the components in a casing and added a chassis for mobility and autonomy. The robot was deployed at an open field in Grant County Park to collect data, and we used that data to determine the most fit crops for that plot by using a kNN clustering algorithm. Our algorithm cross-compares 200,000+ data points from our plant database with the data from the field; the plants from the database with the strongest correlation to the field's conditions were outputted as the most suitable crops. Croptimize provided accurate results due to its constant readings throughout the day, on different areas of the field.

Results:

Croptimize outputted a crop that best fit the tested plot of land. In our experiment, it outputted 'spinach' as the optimal crop for the following conditions: pH levels ranging from 6.5 to 7.1, above-soil temperature ranging from 56 to 74 degrees Fahrenheit, roughly 8 hours of sunlight (at an average of 890 lux), and humidity levels ranging from 63% to 68%. When we tested different parts of the park on different days, the robot received different input values and outputted other fit crops for the plots of land. They included artichoke, cucumber, and guar bean.

Conclusions/Discussion:

The promising results of Croptimize demonstrate the potential it has in reversing numerous inefficiencies in producing crop yields. By testing locations around the world, it can help farmers figure out what optimal crops they can switch to, and figure out where they can relocate their preexisting crop, such that it will grow better. Through practices of crop-switching or relocating crops, which Croptimize enables, farmers can adapt to the imminent and negative effects of climate change on crop yields.

Keywords

Climate change, crop switching, kNN Machine Learning, crop yields, food security

References

Costinot, Arnaud & Donaldson, Dave & Smith, Cory. (2014). Evolving Comparative Advantage and the Impact of Climate Change in Agricultural Markets: Evidence from 1.7 Million Fields around the World. *Journal of Political Economy*. 124. 10.1086/684719.

Biographies

Pranav Palleti is a current junior at Evergreen Valley High School. He has had over 6 years in Python Programming and 2 years in C++. He has earned certification for Deep Learning and Neural Networks from deeplearning.ai, and has engaged in computer science education through programs like Ridge Computing and Computer Science Honor Society. He has led and worked on several other esteemed projects like ScarePest AI and has actively competed in internationally acclaimed competitions, such as the Conrad Challenge, World Series of Innovation, Diamond Challenge, Sciencepalooza, Synopsys Foundation, etc. He has received distinctions in Mathematics and Sciences, including AMC Distinguished Honor Roll and Katherine Johnson 1st Place Award for Engineering. He has been President of the Evergreen Makers alongside Shivam Pathak, Ashok Devireddy, and following Cromptimize developers for over 2 years, which works to develop technical products for competitions worldwide and expand involvement in engineering projects within the local Evergreen Community.

Shivam Pathak is a current junior at Evergreen Valley High School. He has 5+ years of working with several types of hardware, including but not limited to microcomputers, microcontrollers, motors, batteries, sensors, and breadboard electronics. He has an additional 3+ years of programming experience, working with Python, JavaScript, and C++ variants. He has led and worked on several award-winning projects which have involved the use of complex Machine Learning algorithms, advanced robotic engineering, and more. Through these projects, Shivam has received awards and recognition from several internationally esteemed organizations, such as the Conrad Foundation, Network for Teaching Entrepreneurship, Synopsys Foundation, and more. He has additionally taken several advanced math and science courses from Evergreen Valley College. In his free time, Shivam enjoys listening to and creating Indian Classical music pieces. In the future, Shivam aspires to have a professional career in computer science and engineering.

Ashok Devireddy is a current junior at Evergreen Valley High School. He has 5 years of Python programming experience and 3 years of Java experience. He attended COSMOS at the University of California Santa Cruz for Machine Learning and Natural Language processing where he gained machine learning experience he later used to write countless algorithms. Ashok also attained problem solving and technical skills when he attended the prestigious Massachusetts Institute of Technology summer program called LaunchX. He also has hardware experience from working on various projects that include working with a Raspberry Pi and an Arduino. He has participated in highly competitive competitions like the Conrad Challenge, World Series of Innovation, Synopsys Foundation, and many more. He has taken courses at Evergreen Valley College for computer science and advanced data structures.

Pranav Prabhuram is currently a junior at Evergreen Valley High School. He has 5+ years of experience working/learning about agriculture. He is one of the founding members of Evergreen Makers, and has worked on multiple projects that involve machine learning algorithms and advanced robotics. He has 2+ years of business experience and owns and runs Endlessaquarium LLC. Participated in many other competitive business competitions, such as Conrad Challenge, Diamond Challenge, NFTE, and others. He has over a year of experience in HTML and Go. In his free time, he enjoys playing soccer, painting, and keeping aquariums.

Sameer Iyengar is currently a junior at Evergreen Valley High School. He has experience with both hardware and CAD design. In the past, he has worked with a variety of hardware, ranging from basic breadboard electronics, to microcomputers. Sameer also has over two years of experience with HTML, CSS, and JavaScript. In addition to his experience with electronics, he has over a year of experience with 3D printing. He has worked on several award-winning projects, many which have involved the use of complex hardware designs, 3D design, and more. Through these projects, Sameer has received recognition from several internationally respected organizations, such as the

Conrad Foundation. In his free time, Sameer enjoys using 3D software such as Blender as a creative tool. In the future, he plans to take on a career focused on electrical engineering.

Sukhamrit Singh is currently in the 11th grade and attends Evergreen Valley High School. He has 6+ years of both hardware and software engineering experience, working with different types of devices such as Raspberry Pi, Arduinos, and multiple software interfaces. In middle school, Sukhamrit became fond of app development and released his first app, Fractions Quiz, on the Apple AppStore in the seventh grade. The app has over 12 thousand downloads from several countries worldwide. He has also submitted his apps to many competitions such as the Congressional App challenge, where he has been awarded special recognition from the United States Congress for his work. Sukhamrit continues to pursue his passion for app development and has released 6 apps on the AppStore to this day. He has also completed many college courses going over Java, Python, Computer Architecture, Assembly Languages (ARM and MIPS), and Discrete Mathematics. Sukhamrit hopes to pursue a higher-level education and professional career in software engineering in the near future.

Ankit Kapoor is a current junior at Evergreen Valley High School, with roughly 2-3 years of experience in both software and hardware engineering. He has particularly worked with microcomputers such as Arduino and Raspberry Pi, and coded in multiple languages such as Python, Java, and HTML. Ankit has also led or has been part of award-winning projects in multiple international challenges, such as the prestigious Conrad and Diamond challenge. In addition, Ankit has also taken Python and Java courses at Mission College, and has developed several websites and applications using his knowledge in coding. In his free time, Ankit likes to pursue other extracurricular activities such as debate and enjoys researching. In the future, Ankit aspires to pursue a higher-level education and a career in software engineering.