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Short paper

Towards accessible crop-yield estimation

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Abstract This work attempts to meet the significant challenges posed in the agricultural industry around accessible crop-yield prediction. Not only should the designed system provide an accurate prediction of crop yields, but the technology should aim to minimise barriers to entry that may impact the user experience of key user demographics.

Key words

Modern advancements in data science and analytics have dramatically increased the accuracy and ease of crop-yield estimation. Traditionally, however, the technical skillset required to harness the power of such technology has proved a barrier to entry to many who stand to benefit from its predictive power. For example, the system of Muir *et al.* (2018) requires satellite imagery, which is not always available due to cloud cover, and subsequent interpretation.

Our CrYE, the Crop Yield Estimation Tool, aims to increase the accessibility of data-science based yield-prediction techniques for the sugar industry. Operating through a simple web-based interface, CrYE combines the personalised input of users with publicly available weather data to make predictions on the quantum of upcoming harvests.

METHODS

The central architecture of CrYE revolves around the Python programming language. Utilising Python as the backbone of the project homogenises the codebase, allowing for ease of integration among components, as well as substantial developmental flexibility and adaptability. CrYE's architecture can be split into two distinct areas: the front-end and the back-end (Figure 1).

The front-end

This is the user-facing aspect of CrYE - the web application. CrYE's front-end was developed using the React.js JavaScript framework. The front-end handles not only displaying and visualising information to the user, but also accepting information; transporting it from user input to the back-end.

The back-end

CrYE's back-end handles the system's computation tasks, including data gathering, data engineering, and the crop yield modelling itself. When a new prediction request is started via the front-end, the back-end retrieves the necessary weather data from the Bureau of Meteorology and passes it back to the front-end for user amendment. Once this amended data is submitted, the backend runs it through the data models, and provides the prediction back to the front-end for displaying to the user.

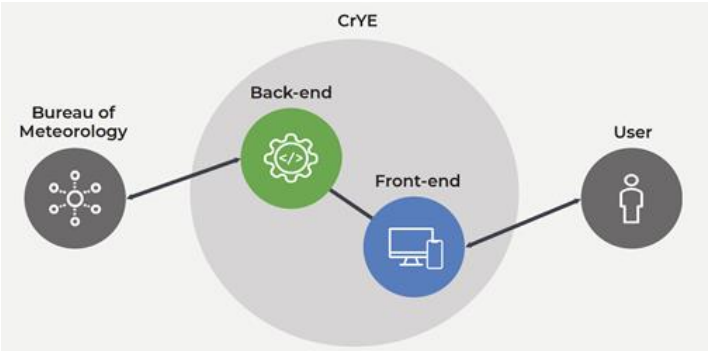

Figure 1. High-level view of the product components.

Neural network

CrYE utilises neural networks - a cutting-edge machine-learning method - to deliver the most accurate possible crop-yield predictions. As the name suggests, neural networks are designed to mimic the human brain's ability to learn and adapt. Neural networks combine extreme computational power with the human-like ability to experiment and adjust in order to produce the best possible results. CrYE's neural network is built on (a) historical yield data and (b) rainfall and temperature data sourced from either the Bureau of Meteorology or directly from the user. Our system automatically populates weather data for the desired region and time period, or allows the user to enter data collected first-hand from their own area of choice. Once the data has been sourced, our trained models identify patterns in the input, learned from data sourced from real-world farms and mills, to deliver estimated crop yields in a matter of seconds. Our models have undergone rigorous training, tuning and evaluation to ensure the most accurate results make it to the user. Included with CrYE are multiple models with means to predict under several different conditions to gauge an accurate forecast in a variety of weather scenarios.

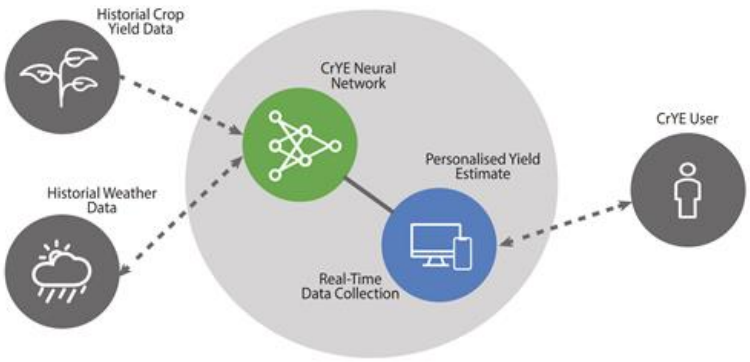

Figure 2. More detailed view of the system.

USER DEMOGRAPHICS

Farmers

Having direct access to yield estimation tools empowers farmers to make more informed agricultural and business decisions. From insuring crops to justifying capital expenditure, giving farmers the ability to make more informed decisions will be a huge step forward in the farming community.

Crop Processors

Crop processors have a very keen interest in crop yield prediction. It allows crop processors to optimise harvesting schedules and add enormous value to their bottom line through an improved understanding of how weather affects their region.

Farm Consultants/Advisors

By simplifying the prediction process at a regional level, farm advisory groups and their clients stand to benefit significantly in reduced overheads and will shift focus to farm-specific analysis.

Researchers

Sugar research organisations will have a keen interest in using this tool, as it will allow them to perform simulative research for the sugar industry. It allows them to enter different weather scenarios and simulate the expected impact this will have on the yield in a given region. This will open up a huge range of research opportunities in the field of agriculture.

USABILITY AND ACCESSIBILITY

The design process for the Crop Yield Estimation Tool's front end was crucial in achieving the goal of creating a product that the previously discussed user demographics would be comfortable using. At the core of every design choice was whether the target user demographics would be comfortable navigating the tool and using the functionality. This design ethic was implemented through extensive user research, usability interviews, and workshops. This research informed terminology used, as well as the data to be shown and the format in which it is presented.

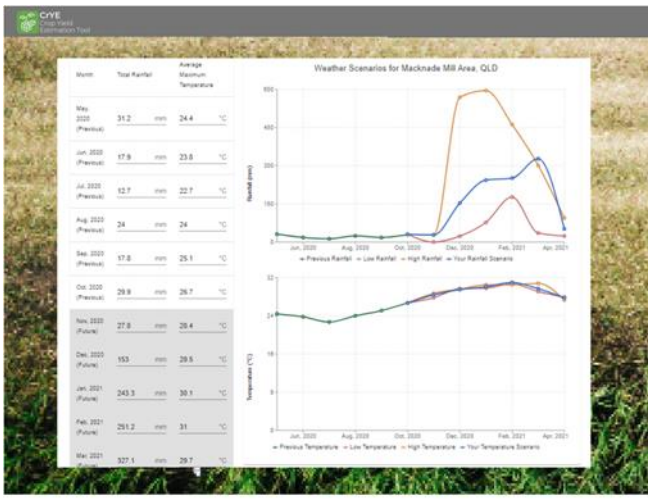

Figure 3. Screenshot of the weather-data entry page.

This led to some interesting design choices, not usually seen in web application design. As an example, users are able to carry out the majority of functions without needing to create an account. A typical web application requires the user to create an account or log in before being able to move past the landing page. However, after extensive user demographic research, it was decided that this would be an unnecessary barrier to entry that would cut out a large section of users who are not familiar with this process.

SCALABILITY

This tool has been carefully designed to allow for scalability in a number of ways. The very nature of the product incentivises its users to improve the product, by providing a simple interface to add data and improve accuracy.

DATA COLLECTION

At the core of every Machine Learning problem is the huge amount of data required to achieve the desired accuracy. Thus, this is the limiting factor of almost all Machine Learning projects. Collecting data for this project was no easy task, as every data point needed to be sourced from external providers on a limited budget.

POSITIVE-FEEDBACK IMPROVEMENT

With the limiting factor for this product's efficacy being the amount of data it has seen – users are able to improve the model by uploading their own data to the system.

In this way, users are incentivised to upload their own data to improve the product for themselves, and as a by-product are improving the system for everyone else as well. This positive feedback loop means that the product will improve dramatically over time.

CONCLUSION

The product that has been created is the result of a carefully thought-out design process in tandem with the leveraging of existing machine learning methods. It has the potential to revolutionise the way farmers and crop processors understand the effects of weather on their crop. This will empower and challenge farmers to think in new ways about their crop and will provide consistency to the crop-yield prediction process.

In its current 'minimum viable product' state, CrYE can produce sugarcane crop-yield predictions for different regions in Queensland within seconds. Whilst CrYE automatically fetches necessary weather data, the option is available for the astute user to utilise their own data, or simply experiment with values to see a multitude of possible outcomes -- quickly.

Whilst this serves as a proof-of-concept, the end goal of CrYE is to service many crop types over many Australian regions. Our team has been working to put this online tool together into a format that is focussed on making the technology accessible to those who stand to benefit the most, and in the future we seek to partner with industry leaders to gain access to the data needed to dramatically improve the accuracy of the CrYE model.

REFERENCE

Muir JS, Robson AJ, Rahman MM (2018) 'Sugar from Space': using satellite imagery to predict cane yield and variability. *Proceedings of the Australian Society of Sugar Cane Technologists* 40: 33-40.