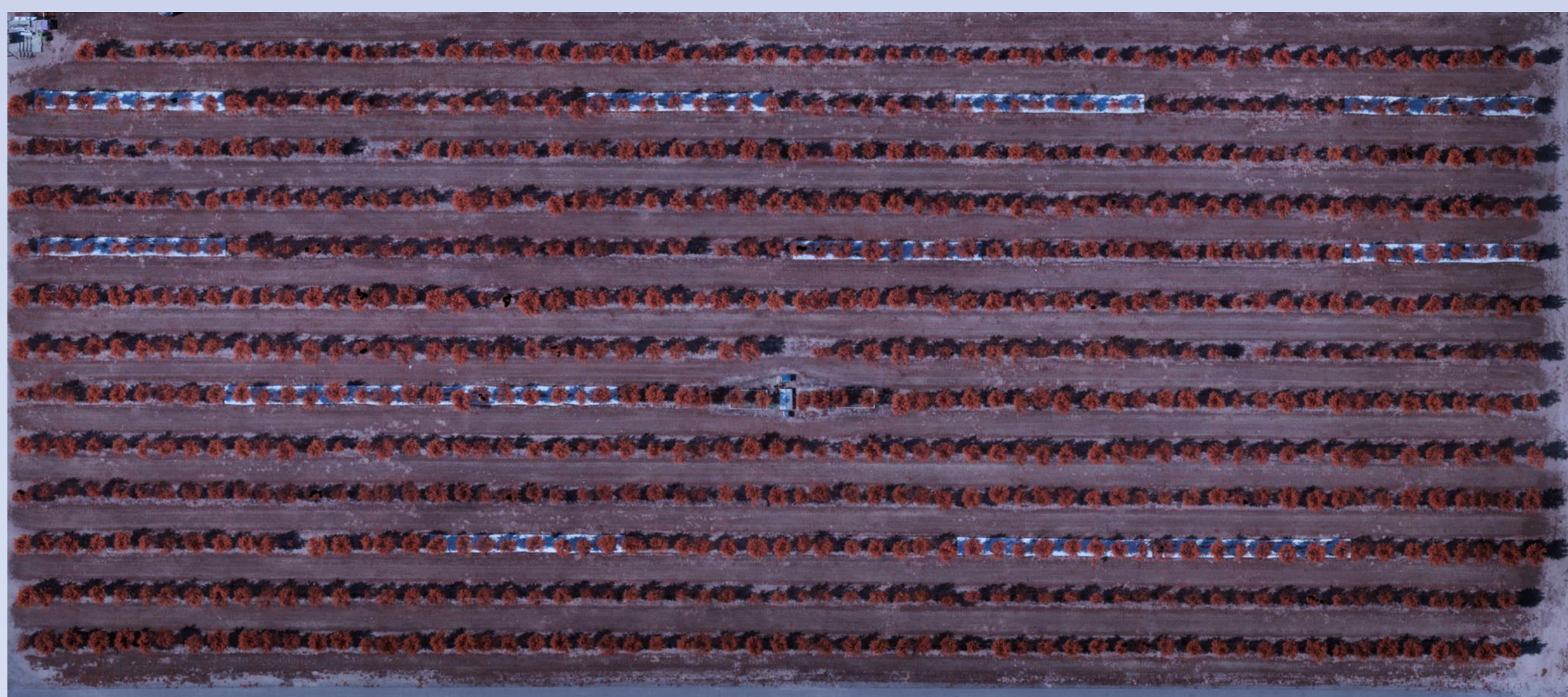


Haoyu Niu, Tiebiao Zhao, YangQuan Chen  
University of California, Merced, 5200 Lake Rd, Merced, CA 95340, USA

Abstract Drones have been widely used in scientific data collection because of their timely, highly detailed and less expensive imagery acquisition. Compared with satellites imagery, remote sensing drones have greater potential in synchronization with more demanding research needs. The satellite overflights are not always at the research sites. The drones, however, can be flown wherever and whenever necessary.

## Sensor technology enables higher resolution images

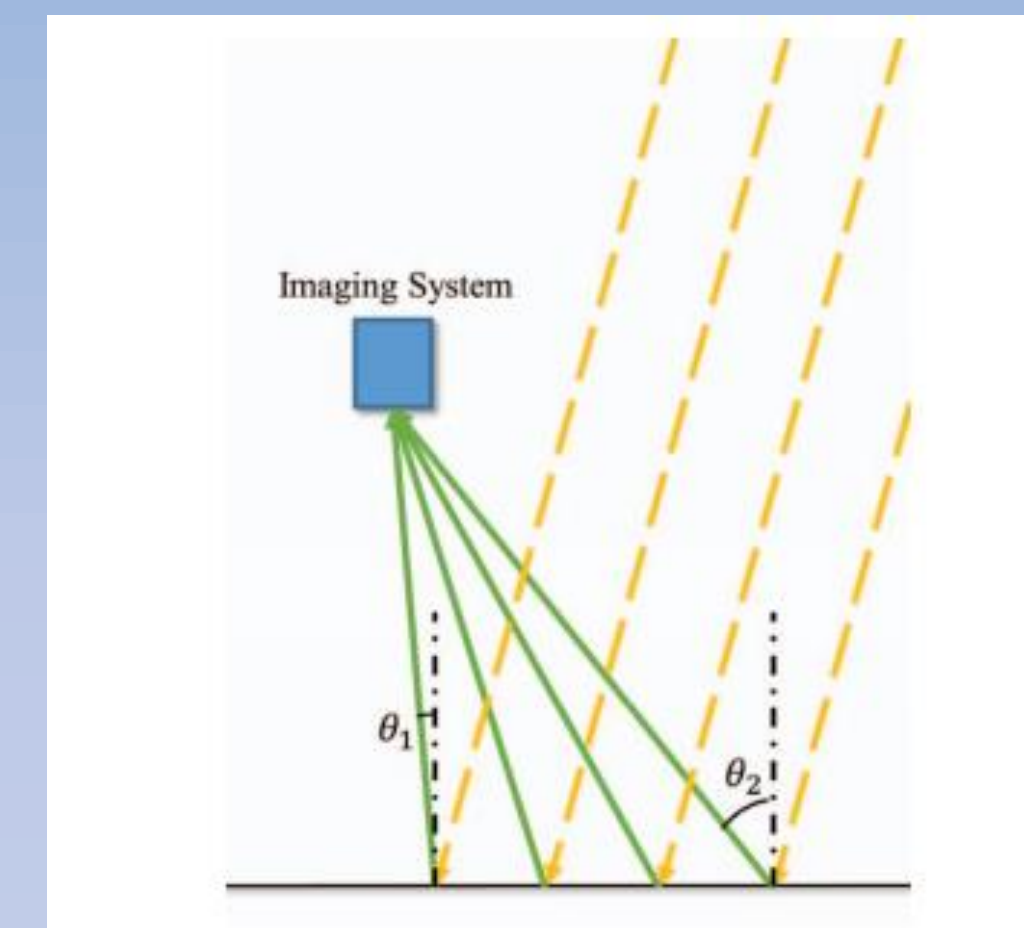
With the development of sensor technology, cameras mounted on drones range from multispectral cameras to thermal cameras and even hyperspectral ones. They are able to capture reliable, scientifically valid data from drones. The pixel resolution for these cameras can be as high as subcentimeter, compared with 30m for satellites. Researchers can apply the high-resolution images in many agricultural applications, such as water stress, yield estimation and crop disease detection. Most importantly, the price of a reliable drone for research can be less than \$1,000 now, which definitely enables researchers to collect data at much lower cost than ever before.



A pomegranate field by NIR Camera(MAPIR) at USDA, Parlier, CA, 93648

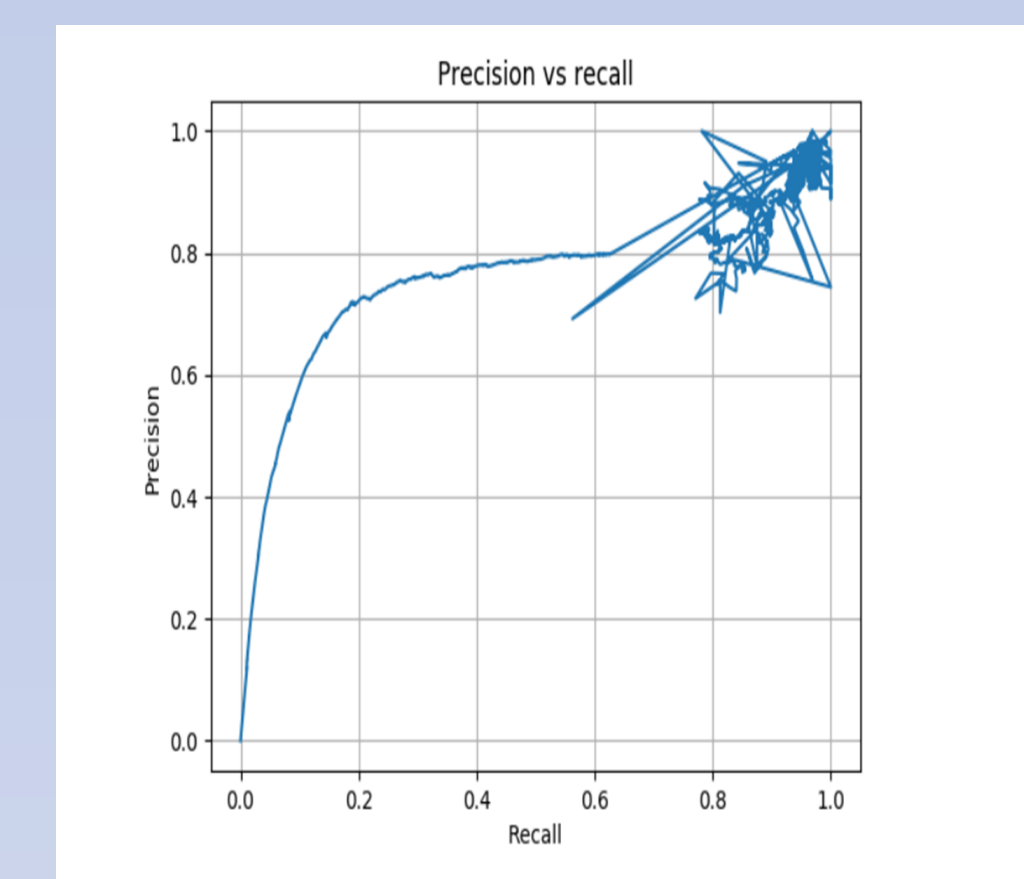
## Data science comes with challenges in agriculture

While drones are representing an important opportunity for data science in agriculture, data science also comes with challenges in agriculture. Drone based remote sensing enables data collection with much higher dimension in terms of time, space and spectrum. This poses a great challenge to process such high-dimension data. It requires particular techniques that are able to handle high-dimension data and process data in a fast speed. Data processing speed is especially important for time-critical agricultural production. It is also difficult to extract reliable, accurate, ground-truth information from big data.



Bidirectional reflectance distribution:

- The varying view angle
- The illuminating angle
- Significantly inconsistent measurements



Machine Learning algorithms

- Large amounts of datasets
- Climate conditions are changing from one section to the next even within a single field



Crop features:

- Time-varying, different growing stages
- Changing climate
- One of the most difficult fields to realize statistical quantification



The hover drone

It can fly 40 minutes with a 9500mAh 6s battery

## Future work

- How to process data in limited time is important for time-critical agriculture production.
- Crop dynamics may change year by year, month by month, or even day by day. How to build an accurate model and capture the invariant crop features is becoming very meaningful yet challenging topic.
- Changing the varying view angle or the illuminating angle can cause significantly inconsistent measurement. How to calibrate effects with ground-truth crop features is important in particular.

## Acknowledgements

Thanks go to Allan Murillo, Stella, Christopher Currier for helping collecting aerial images.

## Contact



Further author information: (Send correspondence to Prof. YangQuan Chen)

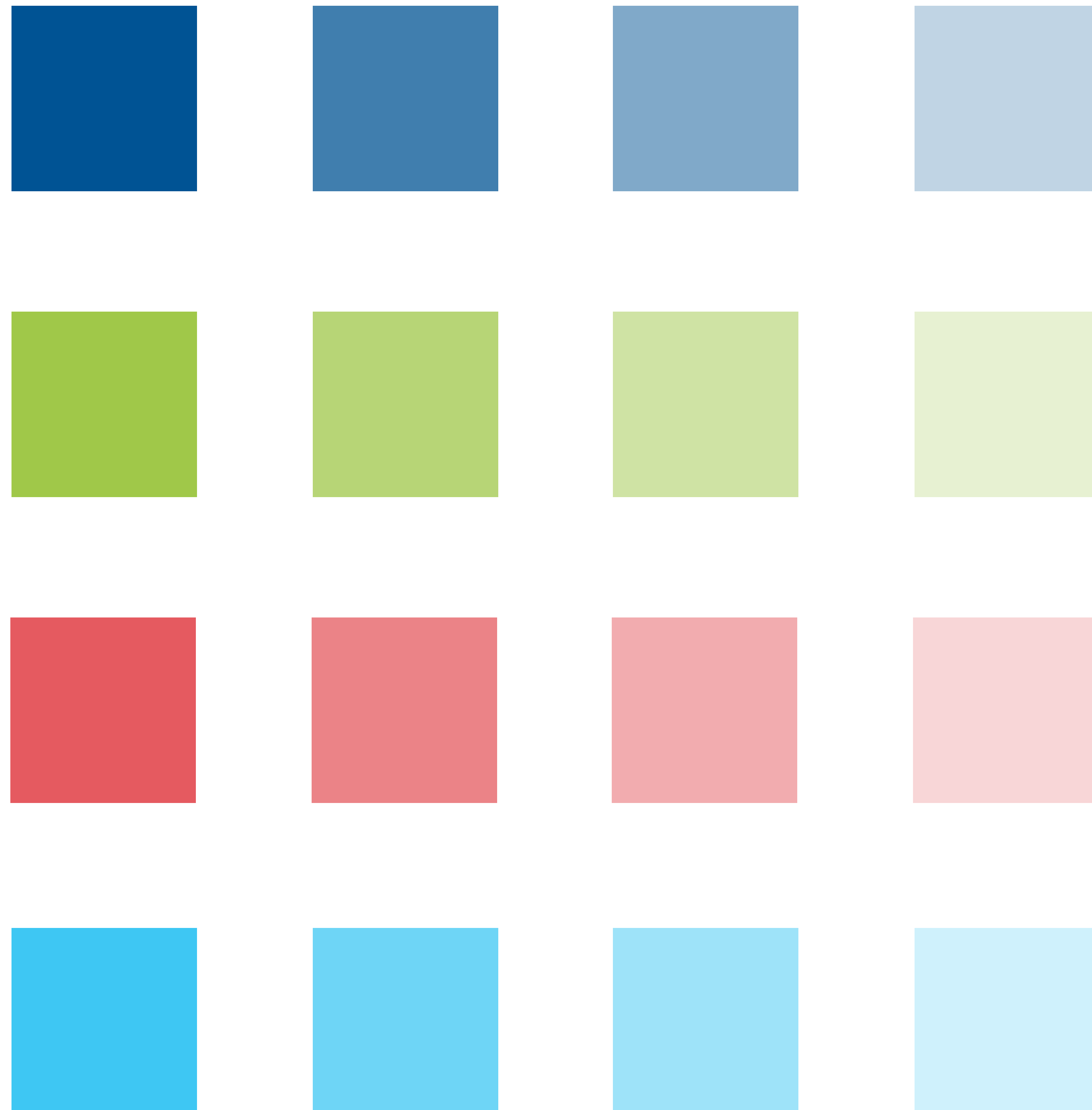
Haoyu Niu  
Tiebiao Zhao  
YangQuan Chen

E-mail : [hniu2@ucmerced.edu](mailto:hniu2@ucmerced.edu)  
E-mail : [tzhao3@ucmerced.edu](mailto:tzhao3@ucmerced.edu)  
E-mail : [yqchen53@ucmerced.edu](mailto:yqchen53@ucmerced.edu)

Drones and remote sensing technology have huge potential to revolutionize agriculture.



## Colors to use in charts and graphs



## Charts and Tables

Since there will be a lot of information on your poster, keeping tables and charts simple and easy to understand is much better than an in-depth and complicated graphic. There are a few simple tricks to simplify charts and tables:

1. Remove unnecessary borders, lines, drop shadows, and backgrounds
2. Remove unnecessary labels and markers
3. Use flat styles and solid colors
4. Highlight important values