POTENTIAL USES OF DIGITAL TWINS FOR COTTON RESEARCH AND MANAGEMENT

Juan Landivar
Jinha Jung
Akash Ashapure
AJ Chang
Sungchan Oh
Texas A&M University & Texas A&M Agrilife Extension
Corpus Christi, TX
Murilo Maeda
Texas A&M AgriLife Research
Lubbock, TX
Javier Osorio
Tommy Gerik
Texas A&M Agrilife Extension
Temple, TX

Introduction

A digital twin is digital representation of a physical system. The combination of the virtual and physical systems allows analysis of near real time data and monitoring of the physical system to identify potential problems even before they occur and can be used to propose management alternatives to optimize the system by incorporating simulation model into the Digital Twin to forecast possible outcomes of management options. We propose to use UAS collected data of cotton crops to develop a digital twin of a cotton field. The Cotton Digital Twin system will use UAS data collected during the season to represent the status of the crop and serves as input for a forecasting simulation model.

Results

To demonstrate the potential uses of this technology in cotton production, a proof-of-concept version of a digital twin was developed using UAS data over cotton fields. The plot was planted at the Texas A&M AgriLife Center at Corpus Christi, Texas during the 2016 season. The time course of canopy cover development up-to 50 and 80 days after planting (DAP) was use as input to the digital twin. The digital twin model accurately forecasted canopy cover for up-to four weeks after each stage of development. Figure 1A, shows the trend in canopy cover development up-to 50 days after planting and the forecasted trend for the following four weeks. Figure 1B shows validation of the digital twin prediction for a 28 days period (four weeks). Based on the current version of the digital twin, prediction accuracy longer than these four weeks period substantially decreased. The digital twin forecasted that the canopy cover would increase from approximately 38% at 50 DAP to 100% at 76 DAP, or 62% increase in canopy cover in a 28 days period (Fig. 1A). This information would be valuable to cotton managers to estimate plant growth regulators, and water needs and possibly the need of nutrients to meet this growth potential.

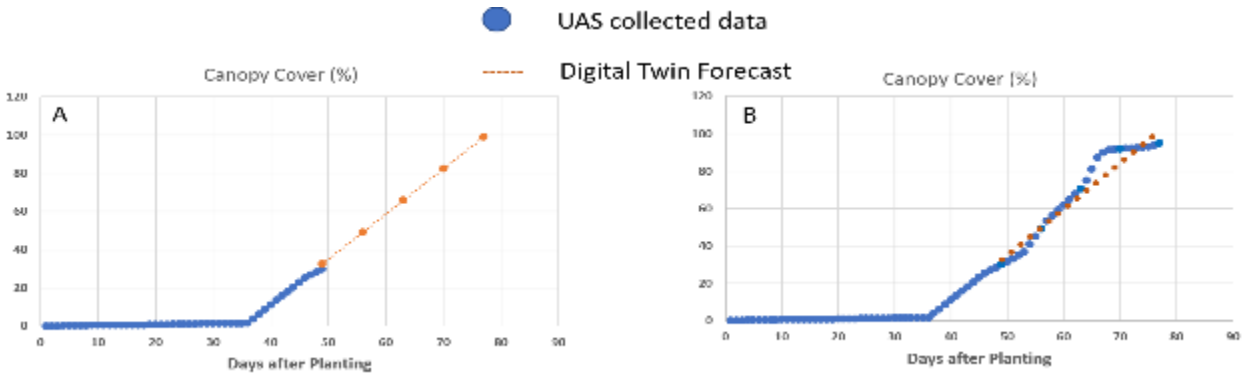

Figure 1A. Figure 1B.

Future work will include 1) improving in-season forecasting capability of a cotton digital twin 2) strengthening additional data input to the system by including multi-temporal features such as plant height canopy volume, Normalized Difference Vegetation Index, Excessive greenness index along with non-temporal features such as white blooms and open bolls count. These data will serve as input to machine learning algorithms such as artificial neural network and convolution neural network for estimating future development in plant growth for in-season management purposes. The machine learning algorithms output will be coupled with simulation models like GOSSYM and EPIC/APEX to simulate the response of management options to crops growth and yield.

Conclusions

1. Digital twin (**alpha** version) forecasted crop performance up to a month ahead.
2. Predicted information can be used to estimate plant growth regulators, fertilizers, water needs and define defoliation timing.
3. Digital twins coupled with simulation models like GOSSYM and EPIC/APEX are powerful tools for agriculture research and crop management.
4. Future work (2019-20) will include further development and validation of digital twin-based Expert System for cotton