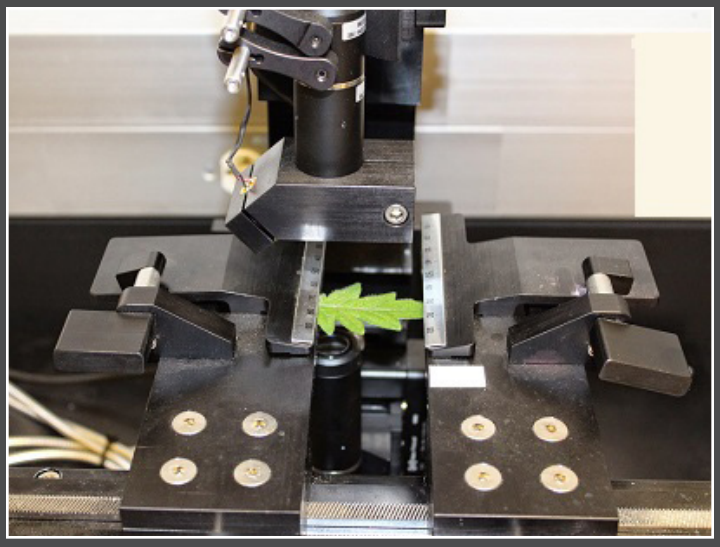
Leaf Analysis

Galil DMC-4020 Moves Unique Instruments



At a time when climatic stresses are resulting in chronic water shortages that impact agricultural output, and with population pressures demanding ever-better farm yields, efforts to breed drought-resistant crops are vital.

Which is just what Dr. Dan Chitwood is currently researching – how to engineer crops to be resilient to high temperatures and flourish with less water. Dr. Chitwood, who is an Assistant Member at Donald Danforth Plant Science Center, is using genetic resources from naturally drought resistant wild tomato plants native to the Atacama Desert of Peru, and analyzing their effects in domestic tomato plants. His objective is to create domestic plants with the wild relative's resistance to drought. He analyzes the modified plant's leaf structure by imaging sections of the leaf with a white light confocal displacement sensor to determine the thickness of the leaf and its venation, key traits in leaves that contribute to drought tolerance.

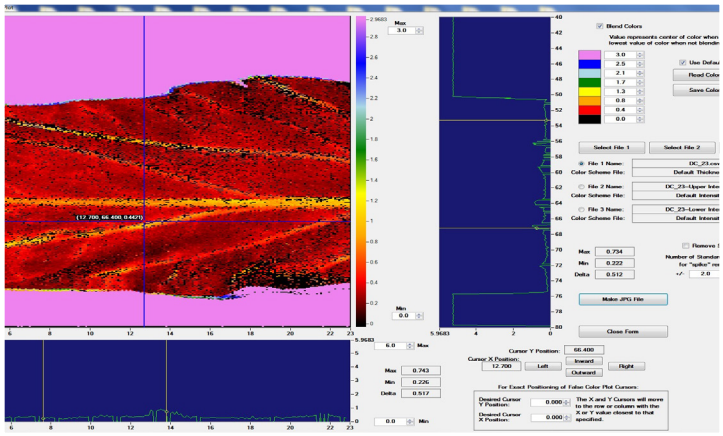
Dr. Chitwood contracted Custom Lab Software Systems, Inc. a developer of precision instrumentation, to build the optical measurement instrument called the Micron Level 3-D Confocal Profiling and Thickness Measurement System. This instrument uses a Galil DMC-4020 to position perfectly aligned beams from white light confocal displacement sensors on the upper and lower surfaces of a leaf sample, and scan the leaf surface in a predefined pattern. It measures the thickness of the leaves very quickly and, when required, can create a very detailed 3-D morphology of the vascular structure.

For a planned research study, the instrument had to be capable of measuring up to 10,000 leaves over a period of two weeks, each with a minimum 200 mm^2 surface area. In order to accomplish this daunting research task, the time to mount and measure each leaf needed to be on the order of 1-2 minutes. Dr. Chitwood also wanted the user interface to be comprehensive, easy-to-use, and very robust. In adddition, the system required a compact design which could be packed and moved effortlessly between planting sites. "There are many reasons why we chose Galil's motion controller", said Terry Chriss, CEO of Custom Lab Software Systems. "The principle reasons were because DMC-4020 had all the features and performance we needed, and the Galil command language is intuitive and easy to learn."

This measurement instrument uses dual Acuity CCS Prima white light confocal placement sensors to perform micron-level measurements of the position of the upper and lower leaf surfaces. The leaf is secured on each end by a quick release clamp system which is connected to a Steinmeyer KDT-310 open frame stage. This stage was selected for its compact footprint and production proven specifications. It is powered by Faulhaber brush-type servo motors, connected to precision ground Steinmeyer ball screws. Once the leaf is mounted, digital I/O on the Galil DMC-4020 is used to turn on laser line generators used as visual cross hairs to allow the operator to quickly determine optimum X and Y starting and ending positions for the leaf to be scanned. A simple mouse click at an XY location on a 2-D representation of the scan area quickly moves the confocal beam to that position on the leaf, and allows the operator to make a real-time measurement of thickness or to confirm the location for the beginning of the scan. A PC running a Windows application written in Visual Basic.net sends motion commands to the DMC- 4020 via an RS-232 serial communication port. The goal is to move the stage so that the beam generates a serpentine scanning path over the entire leaf surface so that measurements of leaf thickness at each point along the path can be used to derive the average leaf thickness. The DMC-4020 controller uses customized firmware in order to send precisely-timed signals to the dual confocal sensors at fixed distances along the vector path. This low-going Output Compare pulse is what triggers the two sensors to take each thickness measurement. Once the scan is complete, the 3-D data is viewable by the user on the PC as a false color image.

"Working with Galil's engineering team to develop custom firmware that met our specifications was easy. We also knew if we had specific questions we could quickly get to an engineer for help. They were always there for us." said Terry Chriss.

Already, members of Chitwood's laboratory have performed a field experiment in which they studied 76 different specially modified domestic tomato lines, each of which has had only one region of its genome modified by replacing it with the genes from the drought resistant wild tomato plant. By using this new technology to measure approximately 5,000 leaves from these 76 tomato lines, and comparing the average thickness of the leaves from the lines to the domesticated parent, they have been able to identify the regions of the genome which have modulated leaf thickness and morphology during evolution and domestication. The long-term goal is to use the analysis to determine what genetic changes are helpful in producing more drought-tolerant, productive tomatoes for a drying planet.



Custom Lab Software Systems
Centerbrook, CT

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