Vision System to Count Microbial Bacteria Colonies

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NI Product(s) Used:
LabVIEW 2010
NI Vision Development Module
NI-1744 Smart Camera

Category:
Life Sciences

The Challenge
A customer was currently counting microbial bacteria colonies by hand and transcribing the counts in a notebook. The process was very time consuming and prone to transcription errors. The counting process was required to observe the effects anti-bacterial medicine had on the microbial bacteria samples in an R&D laboratory.

The Solution
Data Science Automation created a custom solution with a flexible user interface. The counting of the microbial bacteria required some intensive processing; therefore, LabVIEW and the Vision Development Module were the perfect choice.

Introduction
Data Science Automation (DSA) is the premier National Instruments Alliance Partner. DSA integrates commercial off-the-shelf (COTS) components from automation technology vendors to create custom, adaptive automation solutions for research, manufacturing, government and business operations to:

- acquire, analyze, present and manage data
- design, simulate, test and validate products
- monitor, predict, control and optimize processes
- invent, draft, prototype and build machines

for maximum productivity, quality, profit and understanding.

DSA is a certified member of the Control Systems Integrators Association (CSIA) and staffs multiple National Instruments Certified Training Centers with more certified LabVIEW Architects than most integrators.

DSA was chosen because of our responsiveness, diversity of experience developing advanced machine vision applications and our certified process of implementing best practices.

Colony Detection
The vision algorithm that counts the microbial colonies presented a challenge in that the colonies could vary in size, and the colonies could overlap. If colonies are overlapped, the count should detect multiple colonies. The Find Circles function from Vision Development Module was able to accurately detect the majority of overlapping colonies to the satisfaction of the customer (Figure 1). To improve the accuracy of the colony detection, image processing Vis from the Vision Development Module were used to threshold the original image, perform morphology and filter out particles based on the Heywood Circularity factor. In the current implementation, the processing is all performed in the PC. The NI-1744 smart camera was chosen to allow for future enhancements to offload image processing

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from the host PC. The new IMAQ Image Shared Variable allowed for easy retrieval of images acquired by the 1744.

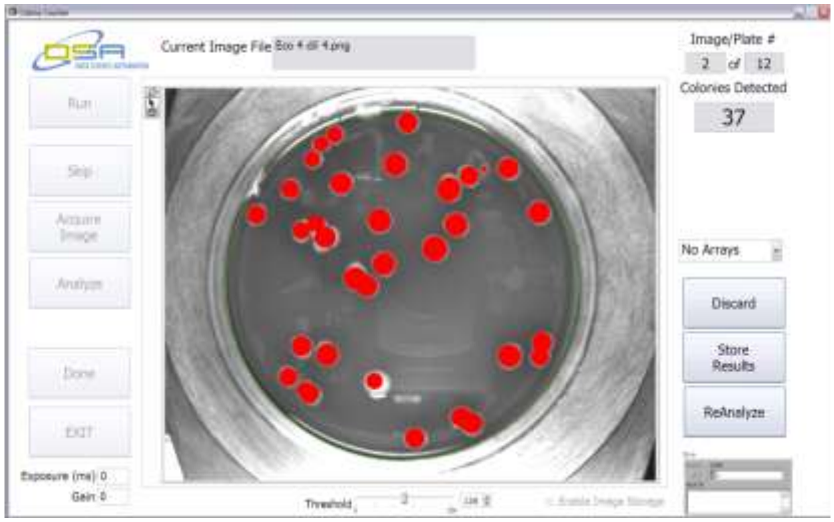

Figure 1. Colony Counting Main Interface

Graphical User Interface (GUI) Operation

The GUI application was deployed on a touch screen monitor so large system buttons were implemented to conduct the testing. The technicians could have hundreds of plates to process and the application kept track of plate counts and stored the count results to a text file, along with header information that the operator would enter at the beginning of a run (Figure 2). The application includes the option to acquire and process live images or cycle through a folder of previously acquired images. The operator has full control while testing to choose when to Acquire (as well as Re-Acquire the same plate) an Image, Analyze the image, Discard the image/plate and also perform various overrides and count modification.

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Figure 2. Data File Header Information User Interface

Taking advantage of the Event Structure, when the operator clicks on the image they can manually add or remove a colony that the circle detection code found. By right-clicking on an improperly found circle, the application will remove it from the results. If they left-click on a colony that was not properly detected, it will add it to the results. This functionality allows the operator to remedy both missed colonies and also false finds. It was added due to the variability of the types of bacteria plates that needed to be processed. The Find Circle algorithm had greater than 90% accuracy, but still was not perfect for colonies that overlapped, due to differences between the types of bacteria colonies being analyzed. For example, E. coli colonies have fuzzy, blurred edges, while others have more distinct edges. The GUI included a control to adjust the threshold limit that is used in the circle detection code so the operator could tweak the circle detection as needed from run to run, or even plate to plate. There was also an option to classify a plate as 'Too Numerous To Count' (TNTC) for plates that were overpopulated with bacteria to the point that it was impractical to count.

Some of the plates to be analyzed had colonies populated in specific areas or 'cells' in the plate in a grid pattern, forming an array of colonies in the overall plate. The software allowed selection of a 4-spot Array, 12-spot Arrays or No Arrays, on a plate by plate basis during a run. If a 4-spot or 12-spot array option is selected, separate Regions-of-Interest (ROIs) are calculated and each ROI/spot/cell is analyzed independently. The individual counts for each ROI is displayed and stored to file. If No Arrays is selected, the overall count for the entire plate is calculated. Regardless of which option is selected, the software calculates the outer ROI by finding the edge of the circular plate using an Edge Detection VI from the NI Vision Development Module. For the 4-spot and 12-spot Array options, ROIs around the edges of the plate are merged with the original outer edge ROI to make sure no false circles are detected outside of plate (Figure 3). This was a potential challenge that was overcome thanks to a few utility VIs in the Vision Development Module. Code was developed to convert the calculated ROI clusters to IMAQ image data types, as images masks. Then the outer ring ROI image mask was merged with the corner array ROIs by using an IMAQ AND operation VI. Without these VIs, it would have taken a considerable amount of prototyping and low-level custom math code to calculate and build each ROI.

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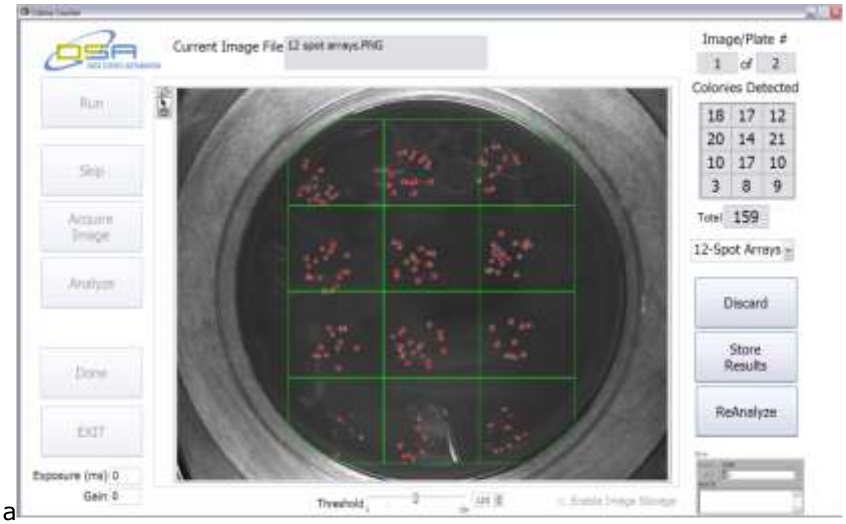

Figure 3. 12-Spot Array Grid

Conclusion

LabVIEW served as the perfect platform for this project due to the need to have an aesthetic, user-friendly Graphical User Interface and the need to perform very flexible, robust processing. Thanks to the NI Vision Development Module, the project took weeks which otherwise could have taken months if the image processing and analysis had to be done by scratch. The Find Circle VI proved to be even more robust than the prototyped code which implemented a Hough Transform algorithm.

Contact Information

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