**Implications of UMD Hyperspectral stress analysis to ARS PRISM research**

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Summary of UMD research

The main conclusions as understood from the UMD presentation and research paper include:

* Spectrum of healthy pixels varies.
* TSVW pixels and healthy pixels share similar spectrum features.
* The OR-AC-GAN model identifies and classifies a) Fake spectrum vs real spectrum, b) Classifies pixels into Healthy, TSVW, Background or Fake spectrum, c) removes outliers that may increase fragility of AC-GAN models
* The OR-AC-GAN model has high sensitivity and specificity
* No optimal bands for detection of either CGMMV, TSVW or PM has yet been identified.

**ARS PRISM current Research Question / Nair lead**: How to determine the condition of the multi-agent telerobotic agricultural system (or a multi-agent telerobotic system) and its expected performance without any a-priori information about the system and its conditions?

Implications for this research

From this UMD presentation the following is implied:

1. For the anomaly detection-based condition monitoring process to work, all sensors including environment measurement sensors like temperature, lighting, pressure etc. would need to be included in the anomaly detection process. This is especially important as the UMD presentation stated that the spectrum of healthy pixels varies due to multiple environmental factors
2. Increased need for Collaborative Intelligence i.e. better HUB-CI methodology as human role is most likely not limited to a “Supervisory” nature.
3. The Anomaly Detection that we are working on will still be relevant as it is performing a process of automated monitoring of the system condition based on the individual condition of all components as well as the correlations between data generated by all sensors. The OR-AC-GAN model is restricted to the issue of making better predictions and diagnoses using hyperspectral imaging which is very important. The Error and Conflict detection, prevention and classification methods described in ARS/Nair report in April provides a collaborative mechanism for management of general errors and conflicts, and also provides insight on the current state of system performance without any a-priori knowledge.

**CI for the ARS**

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|  | **CI function (based on the four types of interaction intelligence (Nof et al. 2015))** | **Tools or methods to accomplish each function in the ARS** |
| 1) | Understanding of the exact tasks required | * Interaction and Collaboration portal with ability for Collaborative Visualization and Comprehension **(CVC)**. All agents should have the ability to query information required and be able to visualize them as images, graphs or plots i.e. **Interactive Data Visualization**. For now a MATLAB based tool will suffice but we recommend Tableau software (which we have used previously) which can generate many data analytics and visualization reports. * **Collaboration Requirement Planning** with **Best Matching** * Simple **Task Administration Protocols** **(TAP)** for workflow management and optimization, or any other mechanism for workflow management. |
| 2) | Resolving conflict and error, and performing online and real time maintenance | * Detection, Identification and Prognostics of errors and conflicts via detection of Anomalies in individual sensor data and also in correlations of data from multiple sensors. **I.e. Unsupervised Anomaly Detection** |
| 3) | Optimizing solutions through learning from similar tasks | * Clustering and Classification algorithms of previous tasks and decisions so as to compare current tasks and decisions to the same. * CRP and Best Matching based on operator expertise/skillset and nature of anomaly or output of AC-GAN model |
| 4) | Avoiding past mistakes | * Database with updated and historical **Time-Series data** for information from all sensors * Interactive data visualization (described in 1) * Classification and Clustering algorithms of previous errors so as to compare current collaborative decisions with previous ones |

Possible CI metrics that can be used

* Number of defects: This can be defined as the number of anomalies that have been classified as existing or potential errors.
* Reduction in defects over time would tell us how well the collaborative error detection and prevention algorithms (Anomaly detection and classification) are working.
* Collaboration cost: Fixed and variable costs can be considered.
* Service level: Minimize the number of false positives i.e. the collaborative system labels a plant as diseased incorrectly, and false negatives i.e. the diseased plant is labelled as healthy.

Questions for UMD/ARO

1. Were some optimal bands determined when it comes to identifying diseased pixels? Some work on it was being done at ARO. On what plants was that project done? What was the conclusion?
2. Question for ARO: We will require a Virtual Private Network (VPN) to connect computers from ARO, UMD and PRISM in order to create a Collaborative ROS Based Testbed. Please decide how you would like to go about that.
3. Question for ARO: A **time series database** would be required for the testbed. ROS can connect to databases (<http://wiki.ros.org/database_interface/Tutorials/Introduction%20to%20using%20the%20database_interface> ). The database must record data from all sensors (imaging sensors, ROS program output, and environmental sensors as well). Will you be leading the creation of this database?