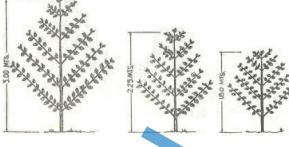
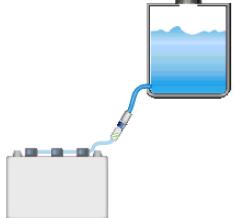
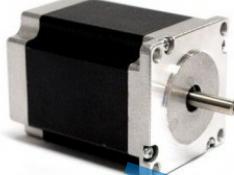
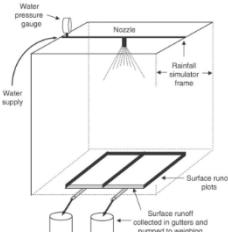
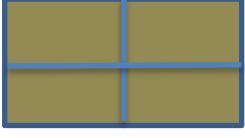
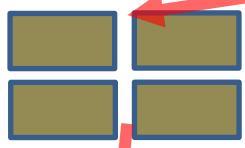
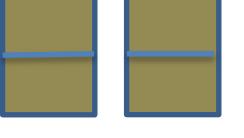
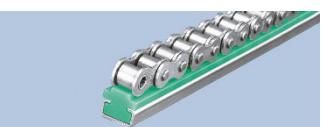
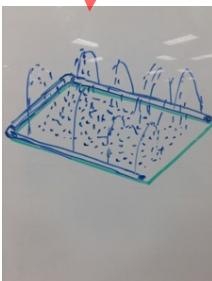


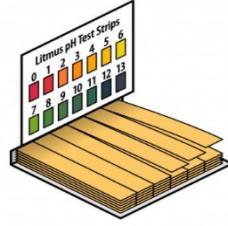
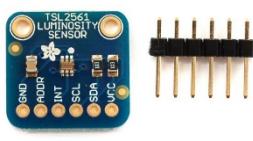
**Table S1.** Morphological Matrix.

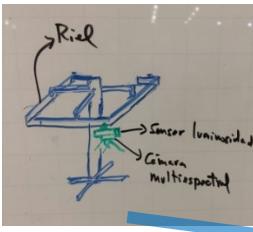
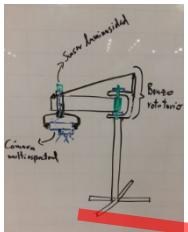
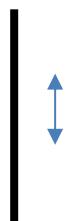
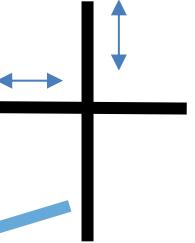
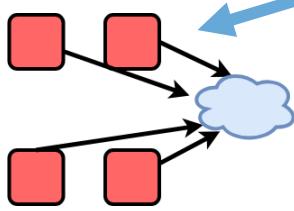
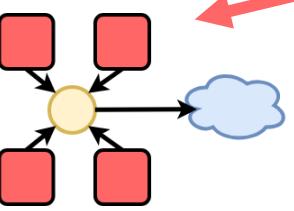
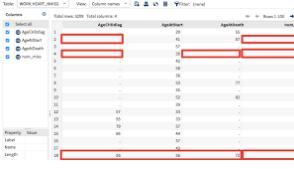
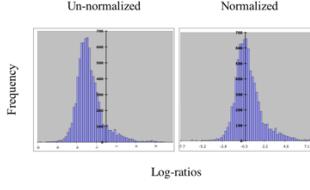
→ CONCEPT 1 → CONCEPT 2

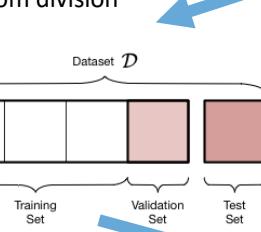
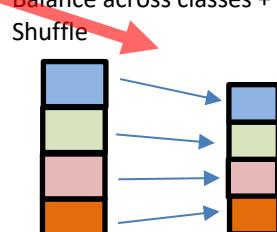
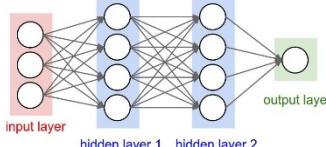
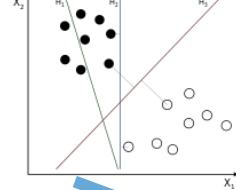
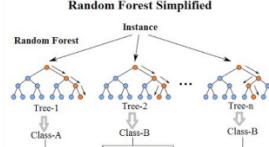
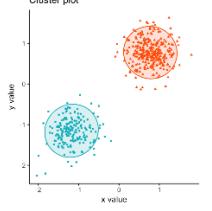
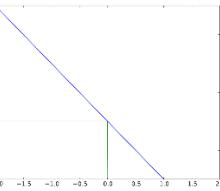
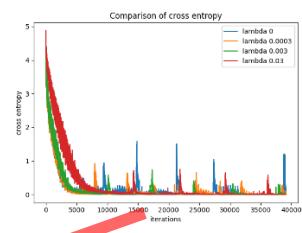
| FUNCTION CARRIER                             |   |   |  |  |
|--|---|---|--|--|
| Function                                     | PROPOSAL 1  | PROPOSAL 2  | PROPOSAL 3   | PROPOSAL 4   |
| 1. Group coffee plants                       | "Almacigo" group<br> | Coffee group with diverse ages<br> | Coffee group in production stage<br>       | Coffee plants between "almacigo" and production stage<br> |
| 2. Store organic matter                      | Plant pots<br>       | Plant bags<br>                     | Crop beds<br>                              | Regular crop disposal<br>                                 |
| 3. Store fertilizer and fungicide            | Bottles<br>         | Tanks<br>                         | Spray<br>                                |  |
| 4. Transport H <sub>2</sub> O                | Pumping<br>        | Gravity from tank<br>            | Normal pressure from aqueduct system<br> |  |
| 5. Transform electrical energy               | DC motor<br>       | Stepper motor<br>                | Servomotor<br>                           |  |
| 6. Combine coffee plants with organic matter | Regular crop<br>   | Single plant care<br>            | Raised garden beds<br>                   |  |

|   |   |   |   |  |
|---|---|---|---|--|
| 7. Distribute fertilizer and fungicide                      | Spray<br>                                  | Pressurized knapsack<br> |   |  |
| 8. Simulate rain with H <sub>2</sub> O                      | Holes in tubes<br>                         | Sprinkler bottom-up<br>  | Sprinkler top-down<br>          |  |
| 9. Divide coffee plants with organic matter                 | Wood, class IV, penetration index = 9<br> | Acrylic<br>             | Bricks and cement<br>          | Plastic, polyethylene and polipropilene.<br> |
| 10. Inoculate Coffee Leaf Rust                              | In-vitro<br>                             | Natural (wind)<br>     | Rub with Coffee Leaf Rust<br> | Brush<br>                                   |
| 11. Assemble inoculated and non-inoculated coffee plants    | One single piece divided<br>             | Independent lots<br>   | Pairs of lots<br>             |  |
| 12. Incorporate fungicide and fertilizer with coffee plants | Sprinkler<br>                            | Spray<br>              | Pressurized knapsack<br>      | Holes in tubes<br>                          |

|  |  |   |   |   |
|--|--|---|---|---|
| 13. Perceive wind velocity                                     | Ultrasonic wind sensor<br>                | Dual wind sensor<br>           | GPRS weather station<br>        |   |
| 14. Perceive volumetric flow rate                              | Flow meter<br>                            | Pluviometer<br>                | Electromagnetic flow meter<br> |   |
| 15. Position multispectral camera                              | Stepper motor<br>                         | Servomotor<br>                 | Manual<br>                      |   |
| 16. Position RGB camera  | Movement by chains<br>                  | Curved rails<br>              | Endless screw<br>             | Small car positioning<br> |
| 17. Isolate each lot of coffee plants                          | Plastic curtains<br>                    | Fabric curtains<br>          | Blinds<br>                    |   |
| 18. Combine simulated rain with isolated lots of coffee plants | Holes in tubes raised from the lots<br> | Sprinkler above the lots<br> |   |   |

|  |  |   |  |   |
|--|--|---|--|---|
| 19. Integrate expert info with isolated lots of coffee plants          | Remote monitoring<br>                 | Visual inspection<br>          |  |   |
| 20. Perceive pH in isolated lots of coffee plants                      | Type drainage<br>                     | Type soil<br>                  | Type general<br>             |   |
| 21. Perceive lux in isolated lots of coffee plants                     | Lux sensor<br>                       | Digital luminosity sensor<br> | LDR<br>                     |   |
| 22. Perceive humidity in isolated lots of coffee plants                | Soil moisture capacitive sensor<br> | DHT-33 (x2)<br>              | SHT-10 humidity sensor<br> | 5TE / DHT-33<br> |
| 23. Perceive temperature in isolated lots of coffee plants             | Type soil<br>                       | Thermometer<br>              | DHT-33 (x2)<br>            | 5TE / DHT-33<br> |
| 24. Perceive electrical conductivity in isolated lots of coffee plants | Conductivity electrode<br>          | 5TE<br>                      |  |   |

|  |  |   |  |  |
|--|--|---|--|--|
| 25. Capture images from multispectral camera | <p>Single rail</p>                | <p>Rotary arm</p>                                    | <p>Manual</p>                                  |  |
| 26. Capture images from RGB camera           | <p>Zig-zag rail</p>               | <p>Straight rail</p>                                 | <p>2-axis rail</p>                             | <p>Elliptical rail</p>  |
| 27. Cluster sensors' readings in a package   | <p>One package for each lot</p>  | <p>One package for the entire crop with lot ID</p>  |  |  |
| 28. Store collected data locally             | <p>USB</p>                      | <p>Micro-SD</p>                                    |  |  |
| 29. Send data package to remote server       | <p>WiFi</p>                     | <p>XBee</p>                                        | <p>Bluetooth</p>                            |  |
| 30. Pre-process data package                 | <p>Missing values to zeros</p>  | <p>Normalization</p>                               | <p>Remove records having missing values</p>  |  |

|   |  |   |  |   |
|---|--|---|--|---|
| 31. Store pre-processed data package                                      | Remote database<br>           | Local database on the remote server<br>                |  |   |
| 32. Divide data into training, validation and test sets                   | Random division<br>           | Balance across classes + Shuffle<br>                   |  |   |
| 33. Process training dataset  | Deep Neural Network<br>       | Support Vector Machines<br>                           | Random forest<br>    | Clustering<br>          |
| 34. Evaluate the candidate model with the validation dataset              | Hinge-loss<br>              | Cross-entropy<br>                                    | Mean-Squared-Error<br>$MSE = \frac{1}{n} \sum_{i=1}^n (y_i - \hat{y}_i)^2$                             |   |
| 35. Visualize the results through a simple interface using some test data | Develop a web interface<br> | Develop a software to automatically send e-mails<br> | Develop an app<br> | Use Thingworx PaaS<br> |

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