Paper Automation Dataset

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1. Objective

The objective of the dataset provided is:

- To allow vendors to understand the application that Pulmac is providing
- To allow Pulmac to explain the nature of the data that will be used in automation projects
- To aid in testing of prediction and automation applications

2. General Description

The provided dataset is not obtained from an actual facility. It is generated based on a design by Pulmac to represent what such a dataset might look like. The relationships between variables are known by Pulmac. This dataset is an idealized sampling that ensures a design of

experiments approach, such that the independent relationship of each input to its output is represented in the data. Pulmac can generate new datasets with different variables, dynamics, and gains as needed. The resulting dataset is a CSV file that typically will be approximately 150 MB in size. The dataset includes process dynamics (deadtime, lags) to represent realistic relationships between rows of data in time.

3. Variable Definitions

The following define the variables shown in the columns of the dataset. The top row contains the names of the variables.

3.1. MV (inputs)

Variables with the "MV_" prefix are the process inputs. These are typically IO sampled at a high frequency in the process control system (SCADA or DCS), then historized at a rate that may be slower. These are usually independent variables, but sometimes are coupled to other input variables. The dataset is generated to ensure that independent input variables are moved throughout their span to represent a full spectrum of the process. "MV" is designated because these can be Manipulated Variables in a MIMO control matrix.

Some typical variables are:

3.1.1. MV_WireSpeed

This is the speed of the paper machine, typically Feet/Min

3.1.2. MV_SWSpecificEnergy

A measure of the energy applied to refining fiber on softwood (SW) furnish. Refining develops fiber to help them better bond. Paper is often composed of several types of furnish, each with their own attributes. This is the energy applied to the softwood furnish. The units are Watts/(Tons/day)

3.1.3. MV_HWSpecificEnergy

A measure of the energy applied to refining fiber on hardwood (HW) furnish. The units are Watts/(Tons/day)

3.1.4. MV_OCCSpecificEnergy

A measure of the energy applied to refining fiber on recycled (OCC) furnish. The units are Watts/(Tons/day)

3.1.5. MV_SWFlow

Flow rate of softwood (SW) furnish. The units are Gal/Min

3.1.6. MV_HWFlow

Flow rate of hardwood (HW) furnish. The units are Gal/Min

3.1.7. MV_OCCFlow

Flow rate of recycled (OCC) furnish. The units are Gal/Min

3.1.8. MV_ThinStockFlow

Flow rate of thin stock. This is after the different furnishes have been blended and diluted as it approaches the paper machine. The units are Gal/Min

3.1.9. MV_ThinStockConsistency

Consistency is the ratio of solids, primarily fiber, to the total volume of flow. Pulp is very dilute as it approaches the paper machine. The units are Solids/Volume %

3.1.10. MV_FillerFlow

Filler material is added to address special quality properties. The units are Gal/Min

3.1.11. MV_PressLoad

A wet sheet on the paper machine is pressed to remove water and strengthen bonding. The units are Pounds/Linear Inch

3.1.12. MV_SteamPressure

The last step of drying a sheet of paper is to apply steam to heat the sheet and evaporate excess water. The units are Pounds/SquareInch

3.1.13. MV_BlendChestLevel

The blend chest is where all furnishes are combined and delivered to the paper machine. The units are % level.

3.1.14. MV_BlendAgitatorSpeed

In the blend chest is an agitator to ensure the furnishes are well blended. The units are Rounds/Min

3.1.15. MV_JettoWire

At the front of the paper machine, a jet of blended and dilute furnish is squeezed through a narrow and wide slot onto a permeable screen to drain water. The ratio of the jet velocity to the wire speed is measured. The units are JetVelocity/WireSpeed

3.1.16. MV_DrawRatio

A typical paper machine stretches the sheet by running the back part of the machine (machine speed) faster than the front (wire speed). The draw is this ratio. The units are MachineSpeed/WireSpeed

3.1.17. MV_SWFreeness

Freeness is a measure of how much water will drain freely under gravity from a furnish. This variable is the freeness of softwood (SW) furnish. The units are Milliliters

3.1.18. MV_HWFreeness

This variable is the freeness of hardwood (HW) furnish. The units are Milliliters

3.1.19. MV_OCCFreeness

This variable is the freeness of recycled (OCC) furnish. The units are Milliliters

3.1.20. MV_SWPct

This is the percentage of the furnish that is softwood (SW). The units are % Softwood/TotalFurnish

3.1.21. MV_HWPct

This is the percentage of the furnish that is hardwood (HW). The units are % Hardwood/TotalFurnish

3.1.22. MV_OCCPct

This is the percentage of the furnish that is recycled (OCC). The units are % OCC/TotalFurnish

3.1.23. MV_HeadboxPressure

The pressure inside the headbox, which forces the blended furnish through the narrow wide slot onto the wire. The units are Pounds/SquareInch

3.1.24. MV_SliceOpening

The narrowness of the opening in the headbox to force the jet through. The units are millimeters.

3.1.25. MV_MachineSpeed

This is the speed of the paper machine at the end of the machine, typically Feet/Min

3.2. PulpEye

Variables with the "PulpEye_" prefix are inputs from the PulpEye fiber analyzer. This device samples fiber at various sample points and can produce over 300 different properties of the fiber (furnish). Much of this data is not useful for online application, but a portion of it is. This is critically important information for understanding the quality of the raw material being used to make paper. Without this data, it is very unlikely to accurately predict the quality of the paper being produced. The sample rate is much slower than the process control system. These variables may be considered "DV" (Disturbance Variables) in a MIMO control matrix since they are measurements that do not have actuators that can uniquely control them.

Some typical variables are:

3.2.1. PulpEye_SWCrill

Crill is a measure of micro-fibrillation on a fiber. It represents the surface area of the micro-fibrils to the surface area of the base fiber. This is the variable representing crill of a sample point in the softwood (SW) furnish line.

3.2.2. PulpEye_HWCrill

This is the variable representing crill of a sample point in the hardwood (HW) furnish line.

3.2.3. PulpEye_OCCCrill

This is the variable representing crill of a sample point in the recycle (OCC) furnish line.

3.2.4. PulpEye_BlendFiberLength

Fiber length is a measure of the average length of fibers in the furnish. This is the variable representing fiber length of a sample point after all furnishes have been blended.

3.2.5. PulpEye_BlendShiveCount

A shive is a bundle of fibers that have not been separated into individual fibers. The count is the number of shive bundles identified in a volume. This is the variable representing shive county of a sample point after all furnishes have been blended.

3.2.6. PulpEye_Temperature

This is the temperature of the stock furnish. This is the variable representing furnish temperature of a sample point after all furnishes have been blended.

3.2.7. PulpEye_Brightness

This is the brightness of the furnish. This is the variable representing furnish brightness of a sample point after all furnishes have been blended.

3.2.8. PulpEye_DirtCount

Dirt count is the number of solid contaminants identified in a volume of furnish. This is the variable representing dirt count of a sample point after all furnishes have been blended.

3.2.9. PulpEye_Curl

Curl is a measure of how much variance from a straight end-to-end shape for fibers in the furnish. This is the variable representing fiber curl of a sample point after all furnishes have been blended.

3.2.10. PulpEye_Gamma

Gamma is an optical property of the furnish. This is the variable representing furnish gamma of a sample point after all furnishes have been blended.

3.2.11. PulpEye_Kappa

Kappa is a measure of the amount of lignin remaining on fibers after the pulping process. This is the variable representing furnish kappa of a sample point after all furnishes have been blended.

3.2.12. PulpEye_BlendFreeness

This is the temperature of the stock furnish. This is the variable representing furnish temperature of a sample point after all furnishes have been blended.

3.2.13. PulpEye_BlendCrill

This is the same freeness definition as applied to the "MV" inputs above. In this case we are measuring the freeness with PulpEye after all furnishes have been blended.

3.3. QCS

Variables with the "QCS_" prefix are inputs from a quality control system. Every paper machine has a QCS which measures important quality properties at the reel (end) of the paper machine. A scanning frame calculates these values approximately every minute. These variables may be considered "DV" (Disturbance Variables) in a MIMO control matrix because a QCS system may already control actuators for these variables. Alternatively, they could be regarded as "CV" (Control Variables) if the MV actuators are included in a Pulmac automation configuration.

Some typical variables are:

3.3.1. QCS_BoneDryWeight

Bone Dry is the weight of a sheet with no moisture, which is the same as Basis Weight with moisture removed. The units are Pounds/3300 Square Feet

3.3.2. QCS_BasisWeight

Basis Weight is the weight of a sheet with moisture, which is the same as Bone Dry Weight with moisture included. The units are Pounds/3300 Square Feet

3.3.3. QCS_Moisture

The percent of the sheet that is water is reflected in % Moisture.

3.3.4. QCS_Caliper

Caliper is the thickness of the sheet of paper. The units are millimeters.

3.4. Lab

Variables with the "Lab_" prefix are lab sample that we are trying to predict and control. These lab samples have time stamps at the time the reel of paper is turned up, so it synchronizes with the timestamps of the QCS data at the reel. In an actual application at a facility, this synchronization will have to be designed and implemented. The results of a lab sample can be an hour or more after the reel turnup occurred. The application is to model these lab results from the data above so that we can have realtime predictions for automation. These variables may be considered "CV" (Controlled Variables) in a MIMO control matrix. The objective is to develop prediction models and deploy for online realtime predictions (Virtual Online Analyzers) and develop a control model (gain matrix) for MIMO automatic control.

Some typical variables are:

3.4.1. Lab_Tensile

Tensile is an index to measure the force to pull a strip of paper until it breaks.

3.4.2. Lab_Tear

Tear is an index to measure the force to continue a tear in a sheet of paper.

3.4.3. Lab_Fold

Fold is an index to measure the number of times a strip of paper is folded back and forth until it breaks at the fold.

3.4.4. Lab_Stiffness

Stiffness is an index to measure resistance of a strip of paper to bend.

3.4.5. Lab_Burst

Burst is an index to measure the force perpendicular to the sheet surface until it breaks.

3.4.6. Lab_RingCrush

Ring crush is an index to measure the compression strength of paperboard.

3.4.7. Lab_Brightness

This is brightness of the final sheet. The units are % reflectance.

3.4.8. Lab_Opacity

This is opacity of the final sheet. The units are % transmittance.