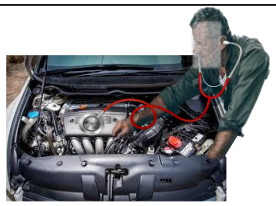
Root Cause Analysis & Multichannel IoT Causal (MIC) digital twin

In June 2018, Galloway, van Schalkwyk and Marian published a seminal paper, "Causal Analytics in IIoT – AI That Knows What Causes What, and When", in the Industrial Internet Consortium Journal of Innovation. Quoting from this paper, "*Knowing the real root causes of events is critical to resolving problems rather than continuously dealing with the symptoms*". This article is a must-read for anyone in IoT interested in going beyond Condition Monitoring (who isn't?!).

Condition monitoring is not new . . . from time immemorial, people have used their senses to assess

	Condition Monitoring	**root CAUSE analysis**
O L D		
N E W		**CAUSAL Digital Twin**

the condition of their tools and machines – the Stone Age man running his finger along the flint knife blade to monitor its condition; or in the last century, the expert mechanic using a stethoscope to trouble-shoot your car engine . . . Fast forward and we now use semiconductor sensors, wireless networks and IoT data platforms to monitoring the condition of end-points continuously. Typically, a Condition Monitoring app will do the following: (1) Visualize single channels of data in plots, (2) Extract simple parameters and display in charts, (3) Automate deviation detection by setting thresholds or bands of normal operation and (4) even do some Machine Learning on the parameters extracted from the data for prediction and other purposes.

When it comes to root-cause analysis, I refer you to the paper cited at the outset but basically, it is an exercise in experimentation. Experts will get together, propose some hypotheses for what went wrong and conduct a series of simple experiments. Of course, this is an off-line cumbersome activity; also, the accuracy of root cause identification is limited by time available and cleverness of the individual experts involved.

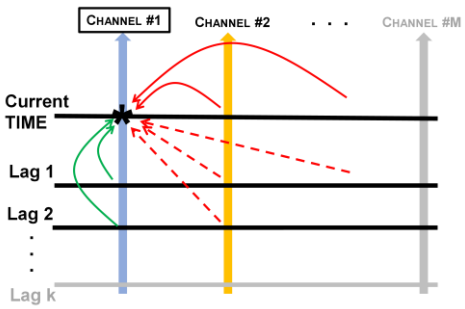
In my recent article, "Multichannel IoT Causal (MIC) digital twin: Counterfactual experiments on Fence Graphs", (August 2021), I discussed the power of counterfactual experiments for eliciting causes and their effects. Important solutions provided in this paper are the proper way to (1) Process multichannel data, (2) Estimate inter-channel (and "self-channel") cause-effects resulting in a (3) Multichannel IoT Causal (MIC) digital twin.

The reason to take MIC digital twin approach to move on beyond Condition Monitoring to root-cause analysis is that quantitative Cause-Effect metrics extracted from multiple channels of data alone will allow for the effective analysis and optimization of processes that results in boosting productivity and efficiency.

Why is that?

Any significant IoT deployment employs multichannel data collection . . . *Because end points that are monitored have some relationships*! Almost all current IoT applications today process single channels, one at a time; that may be sufficient for condition monitoring purposes . . .

Here is a picture of multichannel data. Each channel corresponds to an end-point being monitored. The RED arrows show that inter-channel relationships are NOT ACCOUNTED for in single channel processing; this has consequences!



- Single channel results can be erroneous
- Ignores CAUSE-EFFECT relationships among end-points

MIC digital twin is one way to avoid these missteps and automate root-cause analysis (using rigorous statistical estimation theory).

An overall solution called "FENCE Causal Graph" is described as a MIC digital twin in my article linked above.

We need the FULL PICTURE to take IoT beyond Condition Monitoring to Causal Estimation if we are to deliver operations and productivity improvement prescriptions to business owners.

Dr. PG Madhavan
https://www.linkedin.com/in/pgmad/

#IoT #Rootcauseanalysis #Multichannel #Digitaltwin #Causaldigitaltwin #Fencegraph #Causality