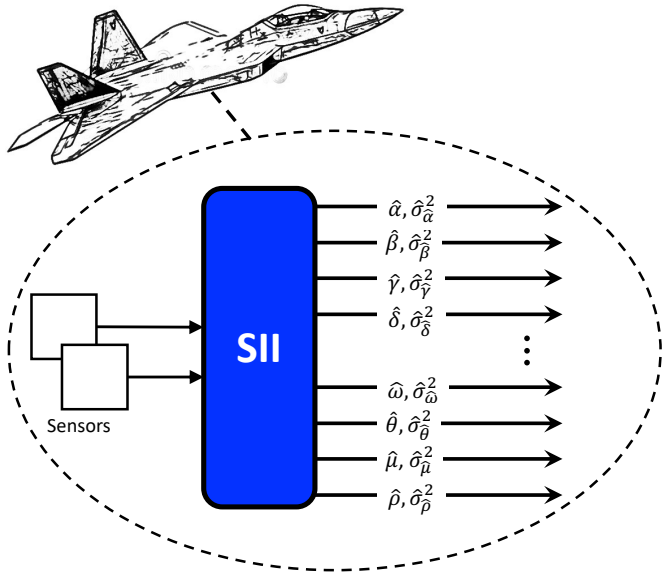


Spatiotemporal Inferential Intelligence (SII)

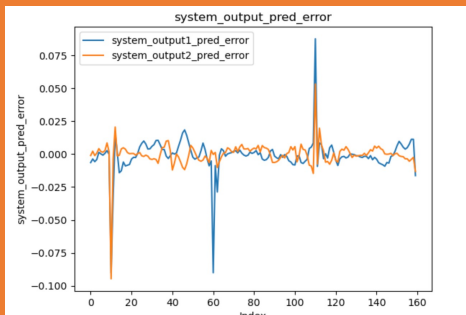
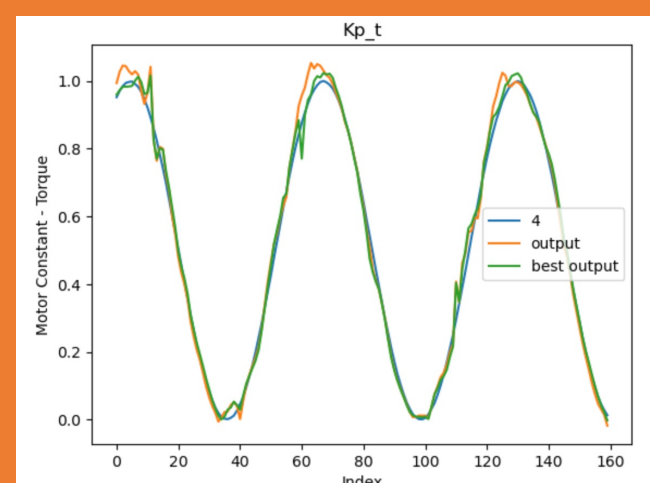
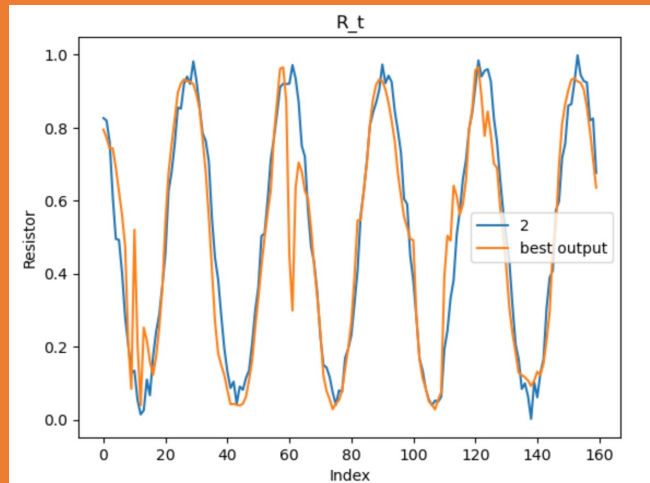
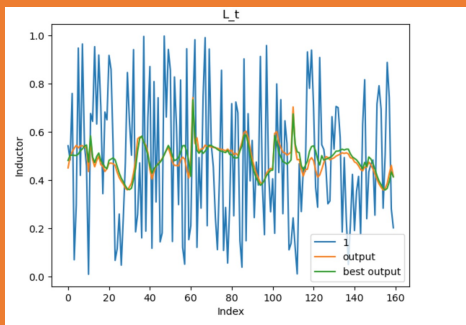
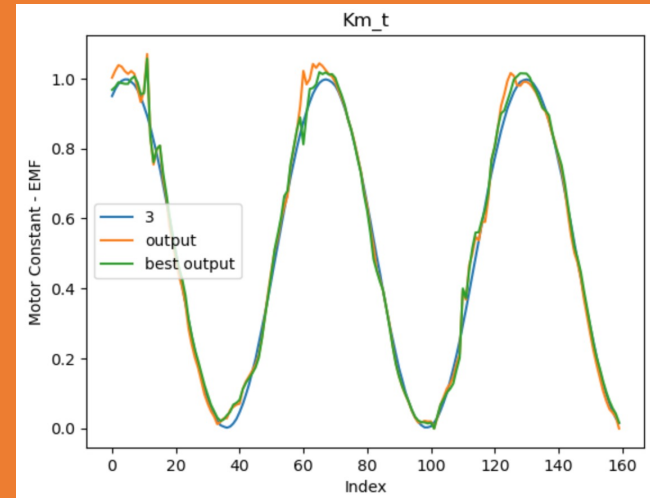
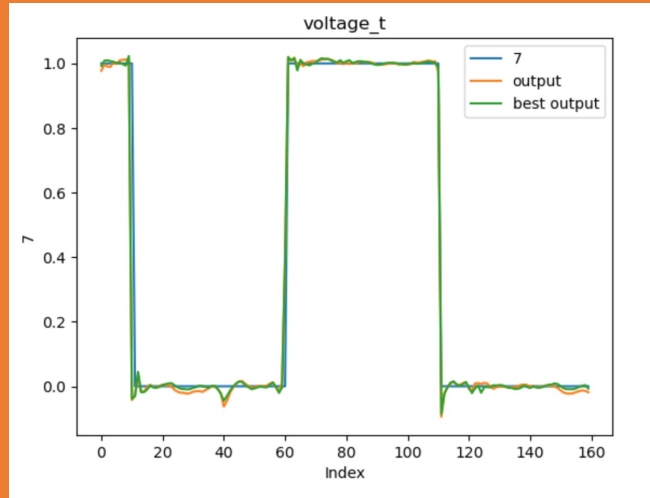
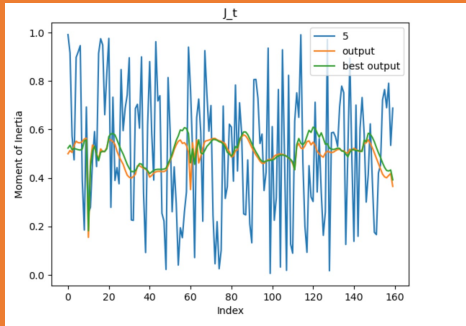


Detect and Mitigate Pending Root Causes ... Before Failures Happen

Feature	Advantage
Monitors system physical attributes that are impractical or impossible to directly measure, while providing quantification of estimation errors	Inferential system transparency, high interpretability, and explainable sensing behaviors
Comprehensive monitoring of infinite variants of a system over an arbitrarily large range of physical attribute behaviors	Detects unusual and unexpected degradations and incipient failures events, outclassing the capability of all other inferential sensors
Accurately estimates essentially any number of physical parameters and disturbances of a complex nonlinear dynamical system utilizing scarce system output measurements (e.g., 2 system outputs for 50 estimated parameters)	Dwarfs the capability of all other inferential sensors, which are limited, in practice, to a number of parameter estimates that is roughly equal to the number of system output measurements used
Adapts to manufacturing tolerances, equipment changes, unanticipated degradations, and failure modes	Eliminates inferential system maintenance and updates due to system wear, maintenance, manufacturing tolerances, degradations, and failures
Accommodates distributed modular training and distributed applications	Supports autonomous systems at scale
Applicable to system and actuator degradations and failures	Applicable for reconfigurable control applications



Proof of Concept



In this example a motor-pump is simulated via a simple system of ordinary differential equations. SII does not receive input that there are parameters behaving in nonsensical ways. The lower left image is the prediction errors of the two signals that SII is monitoring (predicting), current and speed. The other two left hand images represent parameters that are simulated with high noise. The other (4) images show the values of the remaining four parameters, which were simulated with sinusoids and step functions (i.e., voltage, motor emf, motor torque, electrical resistance). The images show that SII estimates all these parameter values based only the prediction errors from monitoring of the current and speed