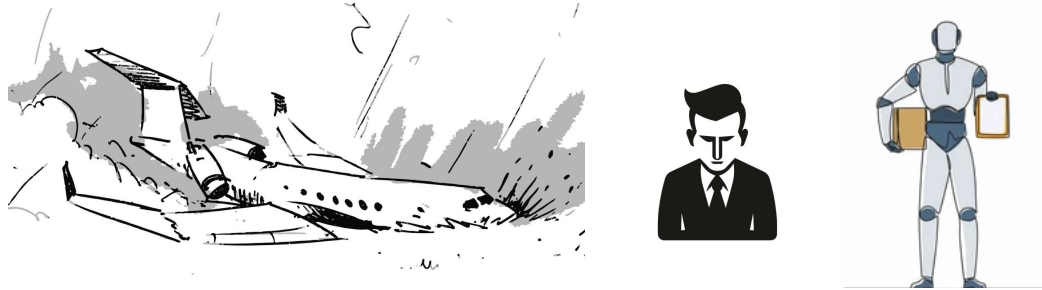# Spatiotemporal Inferential Intelligence – SII™ (AI Software)

1. The Problem

Unknown failure modes are common in machines and can be expensive. Historical parameter estimation limitations have institutionalized many poor-performance scenarios related to unknown failure modes, e.g.,:

- Costly failure modes are effectively *required* to manifest during operations before being discovered and prioritized for correction
- Autonomous mobile operations are designed to move at severely restricted speeds to avoid even sparse occurrences of injuries to humans and expensive damages to the environment


Figure 1. Illustration of a crashed commercial airliner, frustrated engineer, and a restricted-performance humanoid robot.

2. Solution

Spatiotemporal Inferential Intelligence (SII™) provides machines exceedingly high introspective situational awareness and adaptive capability concerning operational degradation and failure modes, contributing to the safe performance of priority mission objectives according to time-varying conditional bases.

SII interfaces with standardly available system inputs and outputs to estimate system parameters at scale. SII provides an unprecedented level of discovery, transparency, and anticipation of system time-varying conditions in real time and in first-principal terms, enabling:

- Complex autonomous machines to anticipate and mitigate <u>unknown</u> failure modes in real time
- Control systems to auto-tune to 100's of unknown system degradations and manufacturing tolerances
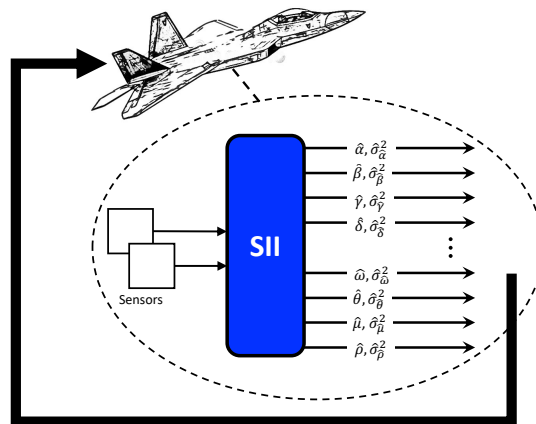
Figure 2. SII is AI software that extracts an arbitrarily high number of unknown and potentially time-varying physical behaviors from only a few indirect sensors concerning a complex dynamical system, facilitating fault-tolerant control, system self-awareness, and safe operations.

Stratos Perception, LLC

2.1. Advantage Relative to the State of the Art (*Secret Sauce*)

Number of Parameters Inferred per Sensed Measurement

Approx. **1**

All Other Inferential Sensors*

More Than **100**

SII
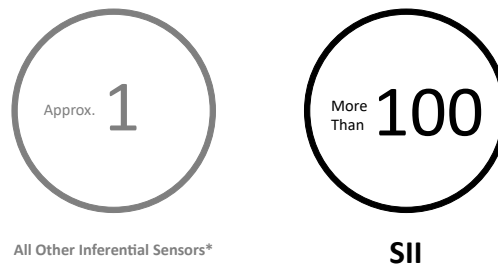
*E.g.,(State of the Art) Emerson, Honeywell, ABB, Siemens, General Electric (GE), Schlumberger, Rockwell Automation, Microsoft, IBM, SAP, National Instruments (NI)

Figure 3. Comparisons of SII's expansive parameter estimation capability to the state-of-the-art.

2.2. Secret Sauce in *Tech-Speak*

SII does the *impossible*, i.e., solves the underconstrained estimation problem for dynamical nonlinear systems. For nonlinear dynamical system $y(t) = f(A(t)x(t))$, where vectors $y(t)$ and $x(t)$ are the system outputs and states, respectively, and matrix, $A(t)$, comprises time-varying system parameters, then **SII** not only estimates $x(t)$, but also estimates all elements of $A(t)$ for any arbitrary size A.

$$SII(y(t)) \rightarrow \widehat{A}(t)\widehat{x}(t) \qquad (1)$$

SII effectively treats a stochastic system with observations, $\{y(t)\}$, as a superposition state, which, when measured, collapses to $A(t)x(t)$ (as expressed in Equation 1), with separable observable features $A(t)$ and $x(t)$. This result is impossible for the prior state of the art, which may only estimate a few elements of $A(t)$, roughly equal to the number of elements in $y(t)$.

2.3. Additional Key Features

Feature	Benefit
Quantifies estimation uncertainties	Supports statistical analyses and compliance
Auto-tunes and adapts control systems in real-time to account for system wear, maintenance, manufacturing tolerances, degradations, and failures	Supports control authority retention during failure modes; Eliminates inferential system updates due to component wear; Maintains subsystem interoperability in response to maintenance and manufacturing tolerances
Integrates with model-based system engineering (MBSE) software	Supports generalized failure management

3. Seeking
Commercial partner and investment support for:
- Field testing access concerning control and monitoring problems of commercial interest

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