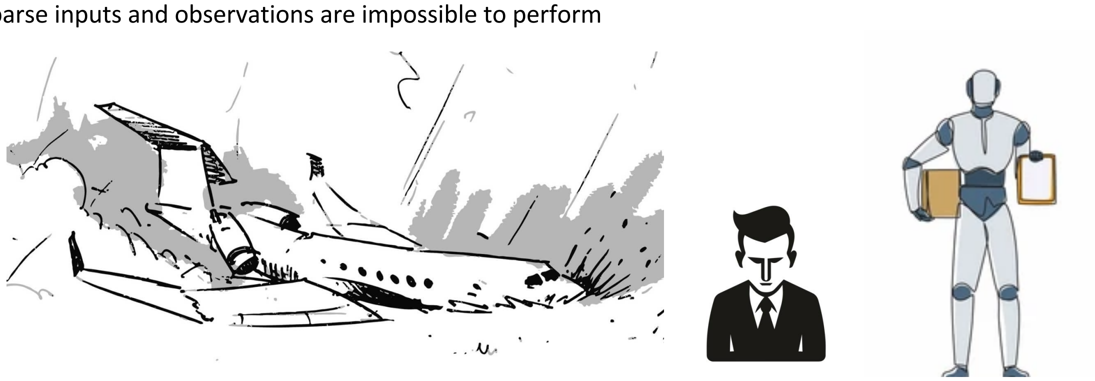
Stratos Perception

# Spatiotemporal Intelligence – SI™ (AI Software)

## 1. The Problem

Relative to safety, reliability, and adaptive control objectives, machines are often severely *underdetermined estimation problems*. Such problems, according to the state-of-the-art in estimation theory, are impossible to solve. Accordingly,

- Too often, costly and catastrophic failure modes can linger in machines, remaining unobserved until the failure happens, causing high risk to spacecraft, submarines, complex ground facilities, and other expensive, potentially human-rated and remotely deployed systems
- Autonomous mobile robotic systems deployed among humans are often designed to move at severely restricted speeds to avoid even sparse occurrences of injuries to humans, curtailing the effectiveness of robotics
- Rapid complex autonomous space transportation operations (e.g., certain rapid spacecraft docking or navigation objectives) that rely on the estimation of many time-varying attributes from comparatively sparse inputs and observations are impossible to perform



(a) (b) (c)

**Figure 1.** Illustrations of: (a) crashed commercial airliner, (b) frustrated engineer, and (c) restricted-performance humanoid robot.

## 2. Solution

We have developed a general solution to underdetermined systems. We call such new paradigm in inferential sensing *Spatiotemporal Intelligence* (SI™). It provides machines exceedingly high introspective situational awareness and enables expansive adaptative and predictive capabilities, based on monitored sparse system outputs. SI can infer 100's of parameters of a complex dynamical system model, including nonlinear systems of differential equations, software models, and neural network models, based on sparse observations, enabling control systems to perform novel complex operations in real-time that may have normally required offline support.

SI interfaces with standardly available system inputs and outputs to estimate time-varying system and environmental attributes (i.e., *time-varying parameters*) at scale. SI provides unprecedented discovery, transparency, and anticipation concerning time-varying conditions in real time and in first-principal terms, allowing:

- Complex autonomous machines to anticipate and mitigate unknown failure modes in real time
- Control systems to auto-tune to 100's of unknown system degradations and manufacturing tolerances
- Control systems to continuously, autonomously, and rapidly adapt and reconfigure to serve novel dynamic conditions or complex operational objectives based on sparse sensing, enabling safer and more nuanced robot behaviors in fragile (e.g. densely populated human or expensive remote space system docking) environments

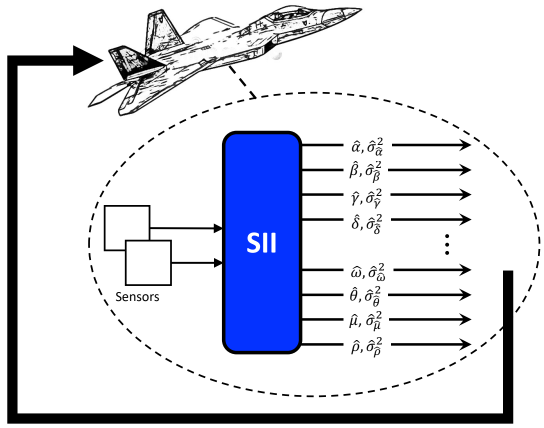
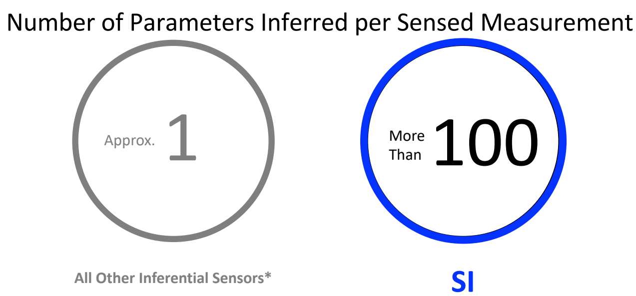



**Figure 2.** SI is AI software that can extract an arbitrarily high number of unknown and potentially time-varying physical behaviors from only a few indirect sensors concerning a complex dynamical system, facilitating fault-tolerant and adaptive control, situational and safety awareness, and autonomous planning.

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




*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 SI's expansive parameter estimation capability to the state-of-the-art.

### 2.2. Secret Sauce in *Tech-Speak*

SI does the *impossible*, i.e., solves the underdetermined estimation problem for dynamical nonlinear systems. For a nonlinear dynamical system $\boldsymbol{y}(t) = f(\boldsymbol{A}(t)\boldsymbol{x}(t))$, where vectors $\boldsymbol{y}(t)$ and $\boldsymbol{x}(t)$ are the system outputs and states, respectively, and matrix $\boldsymbol{A}(t)$ comprises time-varying system parameters, then **SI** (1) not only estimates $\boldsymbol{x}(t)$, but also estimates all elements of $\boldsymbol{A}(t)$ for any arbitrary size $\boldsymbol{A}$.

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

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

## 3. Seeking

We are seeking commercial partnership and investment support for field testing.

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