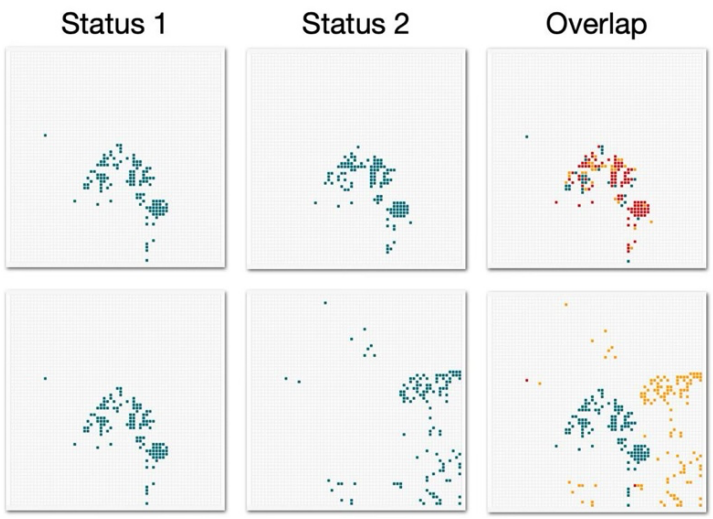
SEMANTIC FOLDING SENSOR FUSION [SF2]

From Sensor Data to System Intelligence

Companies today produce to enormous volumes of sensor and process data, yet often struggle to turn it into fast, reliable insights. In Predictive Maintenance, Condition Monitoring and Process Optimization in particular, many approaches encounter the same structural challenges: conventional solutions are predominantly based on Machine Learning and require large amounts of historical and labeled data, long training cycles, scarce failure data, and substantial computing and integration effort. This makes them expensive, slow and often difficult to implement in real-world industrial environments.

SF2 Systems – Semantic Folding Sensor Fusion – takes a fundamentally different approach.

Our technology makes the state of complex systems understandable in real time. Instead of training complex models on weeks or months of data, existing sensor data is preprocessed and compressed directly where it originates – at the edge – and transformed into a directly comparable representation: semantic digital fingerprints that make system states immediately visible and interpretable. This reduces data complexity, significantly accelerates analysis and eliminates the need for fundamental changes to existing infrastructure.



Similar states produce strong overlap – different states remain clearly separated.

The fundamental difference lies in the underlying principle: SF2 does not analyze isolated measurements or individual anomalies. It analyzes the **overall state of a system.**

Through Sensor Fusion, a wide range of sensor and data sources are transformed into a unified state representation. Many individual measurements become a consistent, directly interpretable representation of the system state. The key point is that engineers do not receive more data. They receive a reliable indication of whether a system is operating stably, moving away from its reference state, or developing toward a critical state.

From Raw Signals to Actionable System Understanding

01 COMPARISON INSTEAD OF ESTIMATION

At the core of the method is a logically traceable comparison and similarity structure. Current states are continuously compared with reference, optimal or failure states.

Changes are not statistically estimated but made directly visible as shifts in system state. This provides a deterministic basis for decision-making: identical states produce identical results – traceable and without black-box predictions.

02 NORMAL OPERATING DATA INSTEAD OF FAILURE DATA

A key advantage of SF2 is that it primarily works with data from normal system operation. Such data is available in abundance, whereas actual failure data is rare and difficult to obtain.

This removes the dependency on complex training processes and enables results to be achieved significantly faster. In practice, failure states do not need to be collected and labeled in large numbers. It is sufficient to establish a clear understanding of normal operation; deviations from that state become immediately visible.

03 INTEGRATION WITHOUT INTERVENTION

SF2 integrates transparently into existing sensor and data networks: sensor data is captured, processed and output as highly compressed state information. This information acts as a set of virtual sensors with significantly greater informational value than the original raw data. In practice, instead of hundreds of individual measurements, users receive a small number of decision-relevant state indicators.

Processing takes place entirely at the edge, either via a virtual edge device – the SF2 Engine – or the physical SF2 Edge Device. Existing systems remain unchanged while new and significantly more meaningful state information becomes available.

The principle is simple: Sensor data in – understandable states out.
Or put another way: We compare instead of guessing.

SF2 is particularly powerful wherever complex systems with multiple sensor sources need to be understood – for example in industrial plants, test environments, manufacturing systems or energy infrastructure. What matters is not the behavior of individual parameters, but an understanding of the system as a whole.

The result is an approach fundamentally different from conventional solutions: less training effort, minimal integration, reduced data complexity and significantly faster results.

Where conventional systems require lengthy analysis phases, SF2 makes existing systems understandable, manageable and immediately usable in a fraction of the time.

THE PARADIGM SHIFT

From Statistical Modeling to Deterministic System Intelligence

The fundamental difference from conventional approaches lies in a simple but disruptive logic: while traditional Machine Learning attempts to approximate the future through statistical analysis of vast amounts of data, SF2 makes the current system state directly visible. Conventional AI treats a machine as a “black box”: it has to be fed failure examples over long periods before it can eventually make a statistical inference that a problem may exist. But machines are not statistical random processes; they are deterministic systems.

SF2 builds on precisely this principle. Instead of laboriously modeling thousands of individual parameters and training models with labeled failure examples, we transform sensor data into a unified, structured representation – the digital fingerprint of the overall system state.

THE AHA-MOMENT

When this fingerprint changes, it is not a statistical probability but a physical change in the system. We do not need to “learn” failures before we can detect them. We compare the current state with a known reference or ideal state.

At a Glance: Why SF2

CLASSICAL AI / ML	SF2 SYSTEMS
Long training cycles	**Rapid deployment based on existing data**
High demand for labeled failure and training data	**Use of reference and normal operating data**
Analysis of individual parameters or patterns	**Understanding of the overall system state**
Complex model development and maintenance	**Comparison-based, traceable logic**
Statistical predictions (black box)	**Deterministic, interpretable results**
Centralized / cloud-based data processing	**Preprocessing and analysis directly at the edge**
High integration and customization effort	**Integration without intervention in existing systems**
Limited scalability with large numbers of sensors	**Multi-sensor capability through integrated state representation (Sensor Fusion)**

SF2 IN ONE SENTENCE

Less Training. More System Understanding.

Conventional systems need to train on large volumes of data to recognize patterns.
SF2 compresses existing sensor data at the edge and transforms it into a directly understandable representation of the system state.

Conventional systems analyze data.
SF2 shows you what is happening inside the machine.

Understand Instead of Train

No lengthy training cycles – results are derived directly from existing data.

Normal Operating Data Instead of Failure Data

SF2 uses normal operation as its reference – rare failure events are not a prerequisite.

Overall System State Instead of Individual Parameters

Rather than individual anomalies, SF2 makes the behavior of the entire system visible.

Sensor Fusion as the Foundation

Different sensor sources are combined into a unified representation of the system state.

Deterministic, Traceable Logic

States are compared, not estimated – identical states produce identical results.

Edge-Native Processing

Analysis takes place directly at the source – via the SF2 Engine or the physical SF2 Edge Device.

Seamless Integration Without Intervention

Integration into existing systems without changing the underlying infrastructure.

Less Data, More Insight

Large volumes of raw data are transformed into a small number of decision-relevant state indicators – “virtual sensors.”

SENSOR DATA → STATE FINGERPRINT → SYSTEM UNDERSTANDING

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