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Cybernizing Mechanical Structures Through Integrated Sensor-Structure Fabrication

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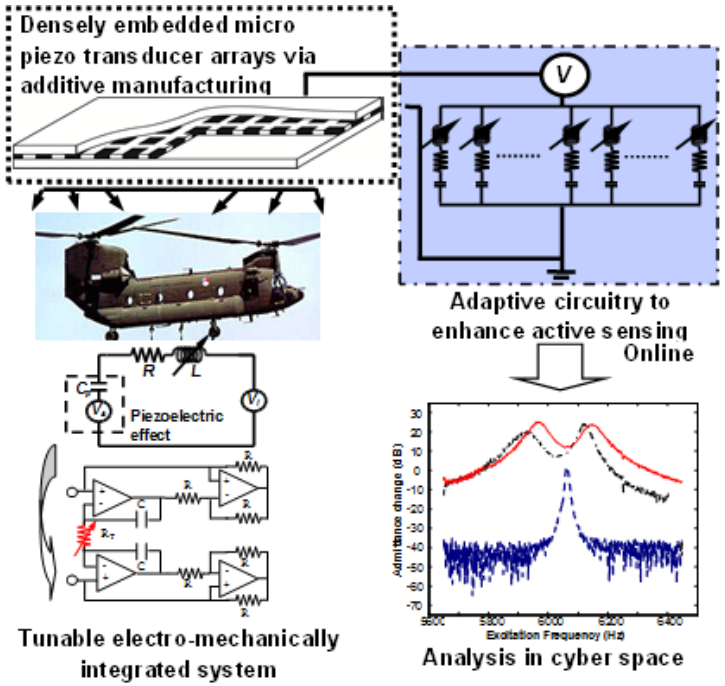
Challenge:

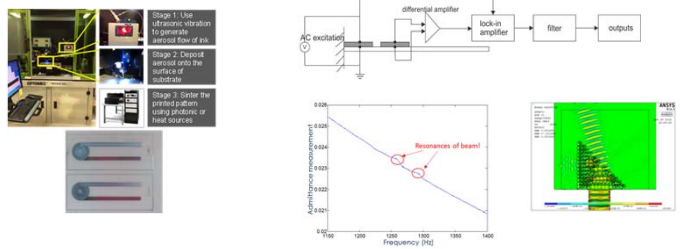
How to perform timely and accurate identification of structural faults to increase reliability/durability?

- Structural faults – continuous in nature, with infinitely many possible patterns.
- Active interrogation – hard to generate high-frequency actuation inside the structure; hard to gather sensing information.
- Sensor data analysis – insufficient information, contaminated by noise/uncertainty .

Solution:

- Synthesis of new sensing modality – duel-field electro-mechanical tailoring with tunable, integrated actuator/sensor units.
- Design of new fabrication scheme – directly insertion of sensing nerves inside of structure.
- Formulation of new data analytics – intelligent and robust inference to identify faults and to guide sensor tuning.





Scientific Impact:

Utilize additive manufacturing to produce structure with densely distributed active sensing elements to facilitate autonomous operation.

- Adaptive sensor/actuator design concept with wave guiding and circuitry integration features.
- Process modeling and optimization of additive manufacturing for structure inserted with active transducer array.
- Hybrid inverse analysis algorithms combining rich sensor data with first-principle models.

Broader Impact:

- Autonomous structural system with self-diagnosis capability can cause paradigm shift in structural design and operation.
- Outcome can benefit aerospace, mechanical, transportation, manufacturing, and other industries.
- Contribute to workforce training by promoting sensing/ manufacturing/ data analytics related research.
- Fundamentally Increase the durability and reliability of composite structures.

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