NSF-1543830 CPS: Breakthroug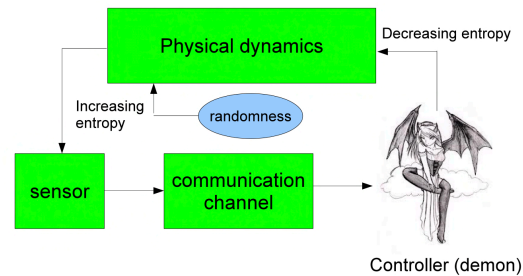h: An Entropy Framework for Communications and Dynamics Interdependency in Cyber Physical Systems: Analysis, Design and Implementation (2015-2018)

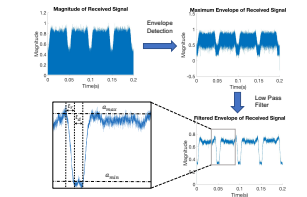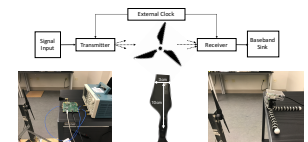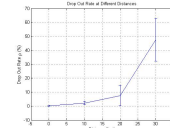## PI: Husheng Li
The University of Tennessee

Challenge:

- Communications are needed for controlling physical dynamics in CPS.
- What is the communication requirement for the control?
- How to design the communication scheme?
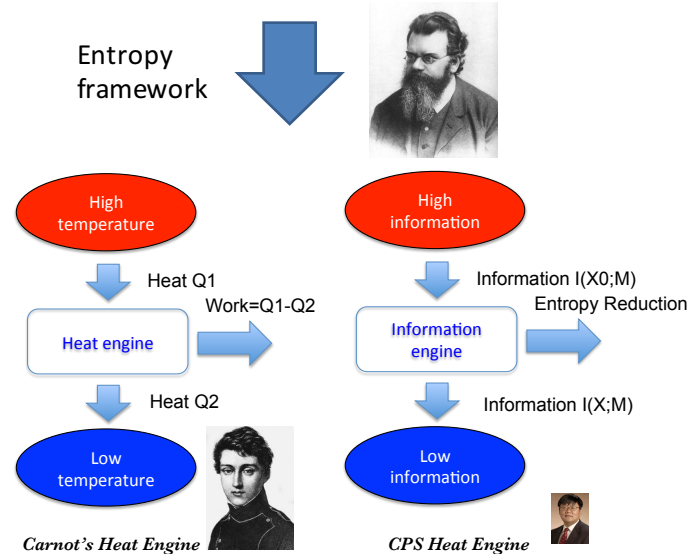- What if the physical dynamics is networked?

Solution:

- Entropy framework: We use entropy to measure the messiness of the physical dynamics. Communications can be considered as negative entropy to compensate the entropy increased caused by random noise (ISIT'2015).
- We also study the propagation of entropy.
- A millimeter wave communication testbed is built to test CPS in 5G.

Millimeter wave communication testbed

Millimeter wave radar testbed

Controller (demon)

Entropy framework

Carnot's Heat Engine

Heat engine efficiency

CPS Heat Engine

Information engine efficiency (CDC'2016)

Experiments:

- UAV networks

Communication in UAVs: we have tested the wireless communication performance on UAVs, in terms of packet drop rate

Millimeter wave for UAVs: We have tested the communication performance damage due to rotating blade in propeller UAVs

Broader Impact:

- The theoretical framework helps to better understand and quantify the communication requirement in CPS. Particularly, it enhances the design of communications in smart grids.
- Two PhD students are involved in the project.
- Three high school students are involved in the project, focusing on the implementation of controlling unmanned vehicles.