Fall Series 2021

Robots, Automation and Learning Systems

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Learning to Control:
The challenge of rewarding good behaviors

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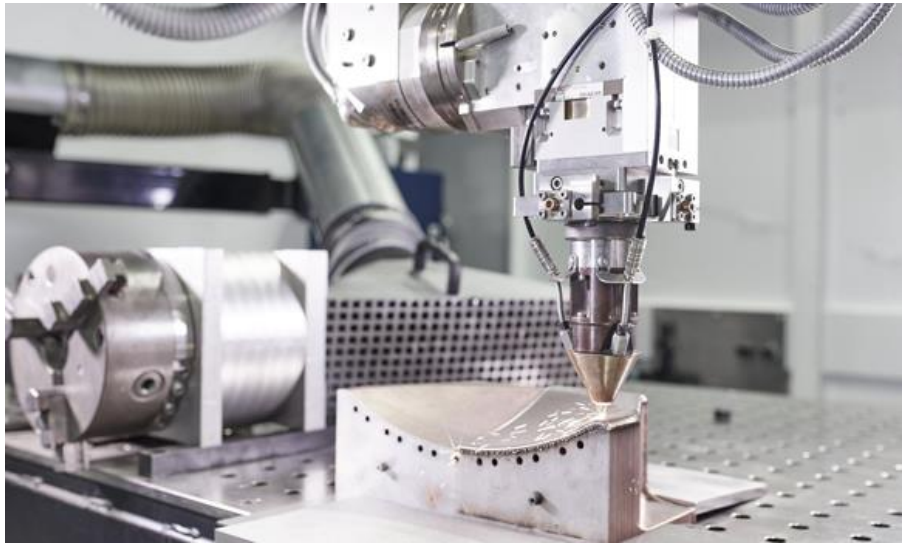
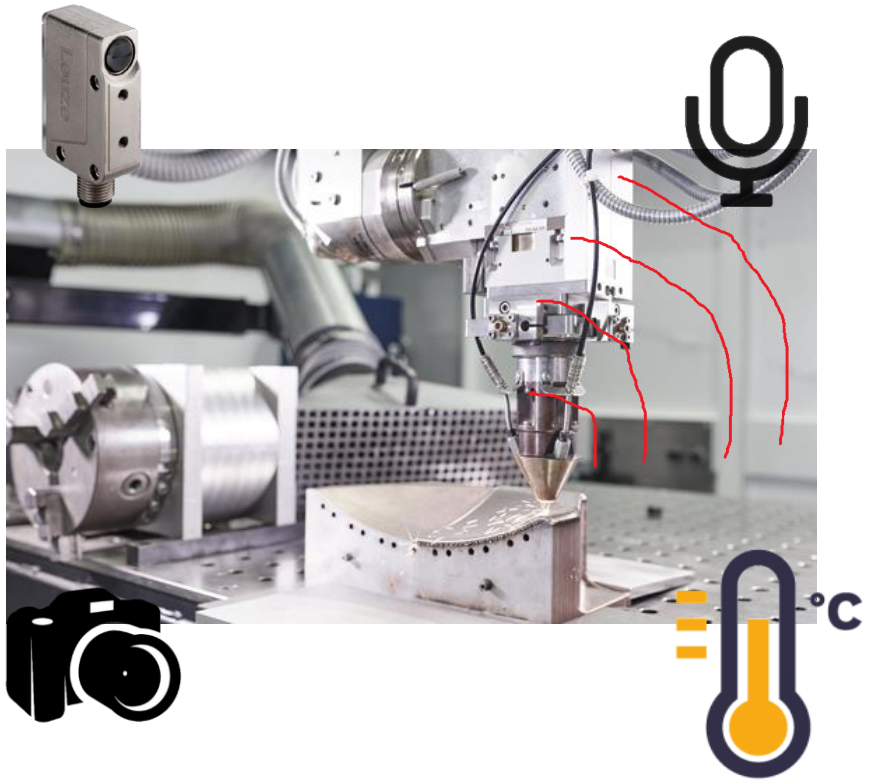
Motivation (why)

- **Additive Manufacturing (AM)** promises to **revolutionize** the **production industry**
- But there are still **limitations** that **prevent** its **mass adoption**:
  - Residual stresses
  - Variability in material properties
  - Stochastic defects
  - Poor scalability
  - Poor **repeatability**
- The **conventional regulators/controllers** can help improve consistency, but they are **not effective**:
  - Time-consuming set up
  - Require a reference observation (target) to track
  - The optimal target is layer-, material-, and geometry-dependent
- **Artificial Intelligence** (specifically, **Reinforcement Learning**) is a promising **solution**:
  - **Learning by doing** – by playing with laser parameters, e.g., **power**, **scanning speed**, …
  - Adaptivity
  - Can learn long- and short-term optimal behaviors
  - *Almost* does not require a priori knowledge



Challenge (what)

- **Learning by doing** is only effective if we can define a way to **incentivize good behaviors**, i.e., keep the vehicle on track for self-driving cars
- But for **AM** processes, the **reward definition** is **challenging**:
  - it should be **universal**, i.e., independent from material/geometry of the sample
  - it should define a local metric for quality (microstructure- and porosity-related?)
  - it should be backed by deep physical understanding
- For AM: What we know
  - Acoustic Emission sensors seem to be material- and geometry-sensitive
  - Optical sensors appear to be a better choice, but still heavily geometry-depending
  - Imaging techniques can help but provide only superficial information



How can we define a reward such that our goal can be described as the maximization of the cumulative rewards?

Support (how)

- Discussion: Do you have **suggestions** on how we can reward RL algorithms for enforcing **good behaviors** to increase AM repeatability?

- Know-how: **Physics** (are there any detectable events related to quality regardless of the material?), **sensing** (are there specific sensors that can be used?)

- Specific equipment: Do you have the mentioned equipment so that we can test limits and possibilities?

Contact

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