

# CELTIC-NEXT

## Project Proposal Pitch

5<sup>th</sup> of October 2023, Online

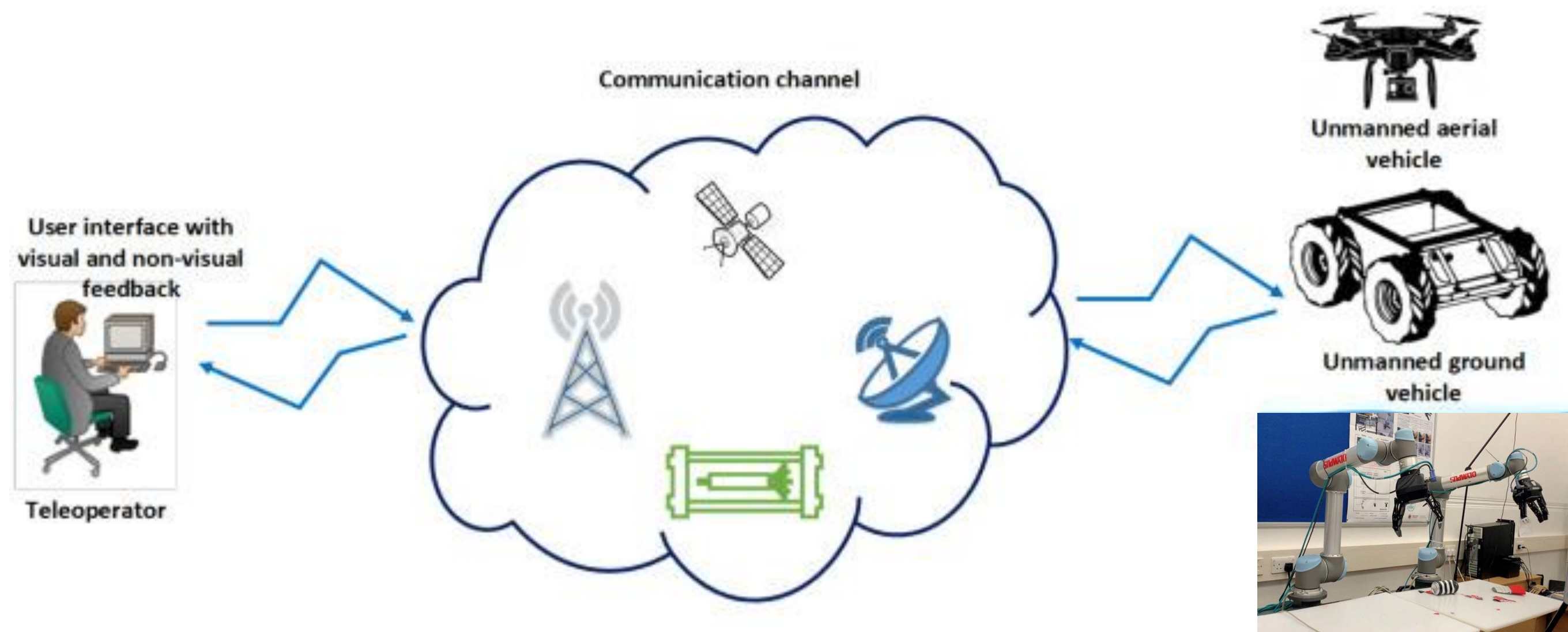
### Teleoperation for Time-critical Tasks

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# Teaser

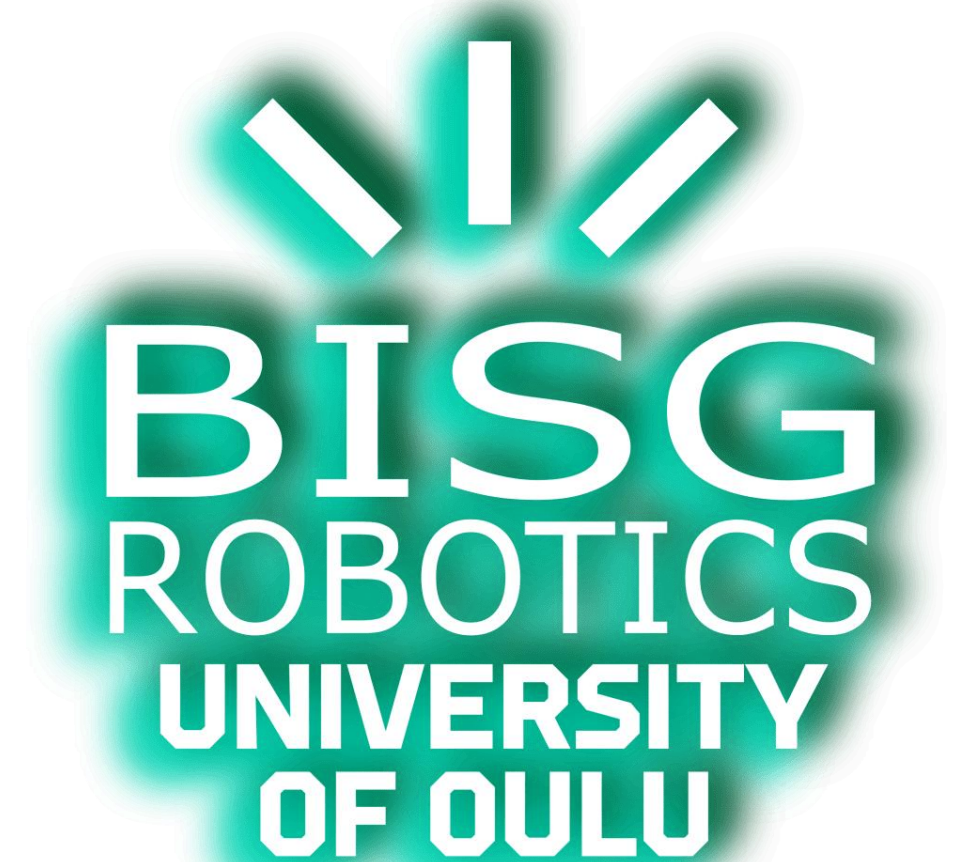
## Internet based real-time teleoperation



**Challenges:** Time-delay, Unstable network, Safety

**Our solution:** Leverage state-of-the-art in control theory, AI, robotics to make existing internet ready to use for **time-critical task** teleoperation

**Key technology:** Stable Control with Delay+AI based Prediction





# Applications and Opportunities

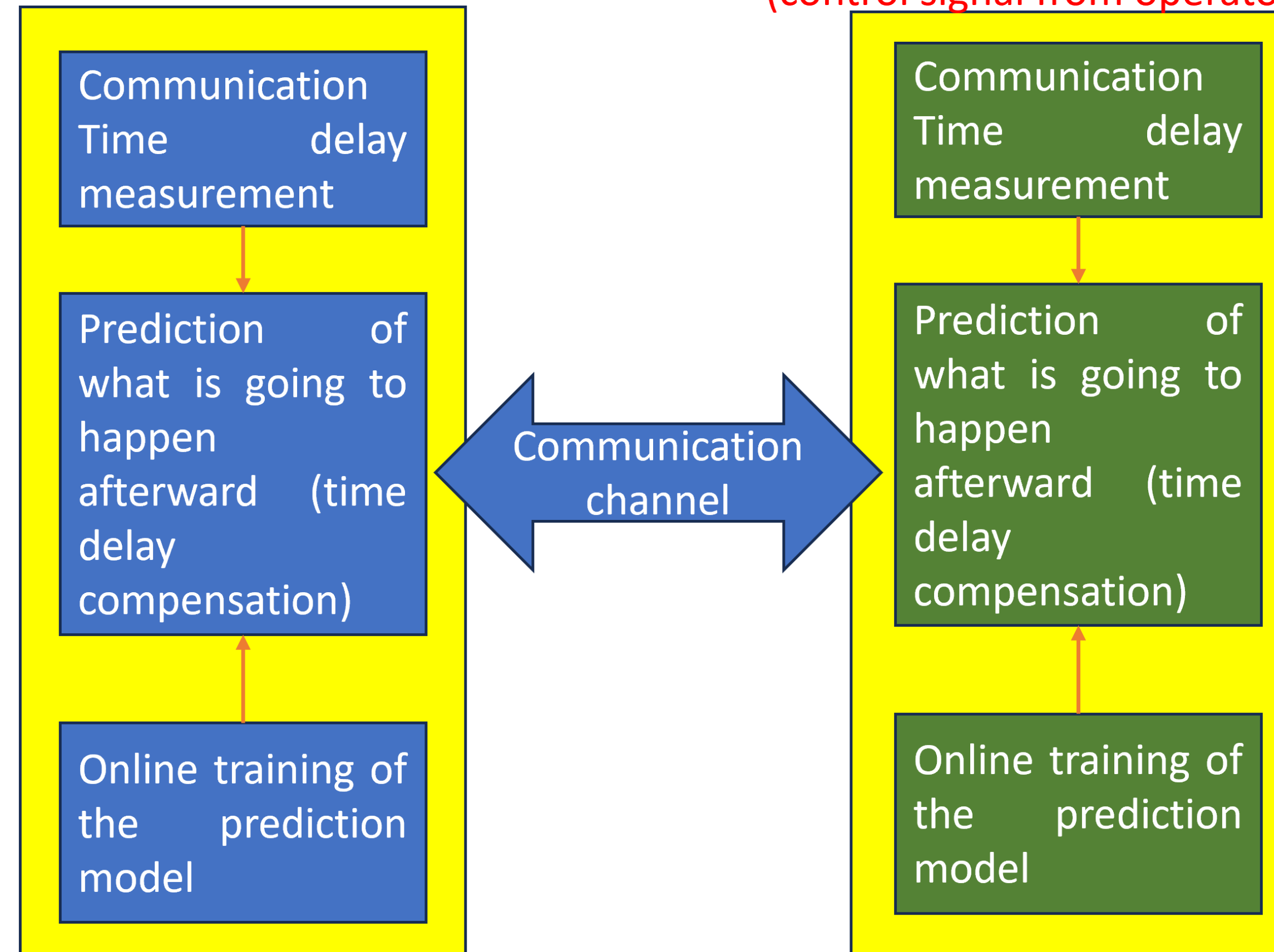
- Applications (time critical)
  - Remote driving
  - Tele-surgery
  - Hazardous environment manipulation
  - Remote health and care
- Opportunities
  - Internet and 5G/6G network are **faster**
  - Robots are more **accessible** and **low cost**
  - Remote operation is **highly demanded**





# Our Idea 1. Online Learning and Prediction

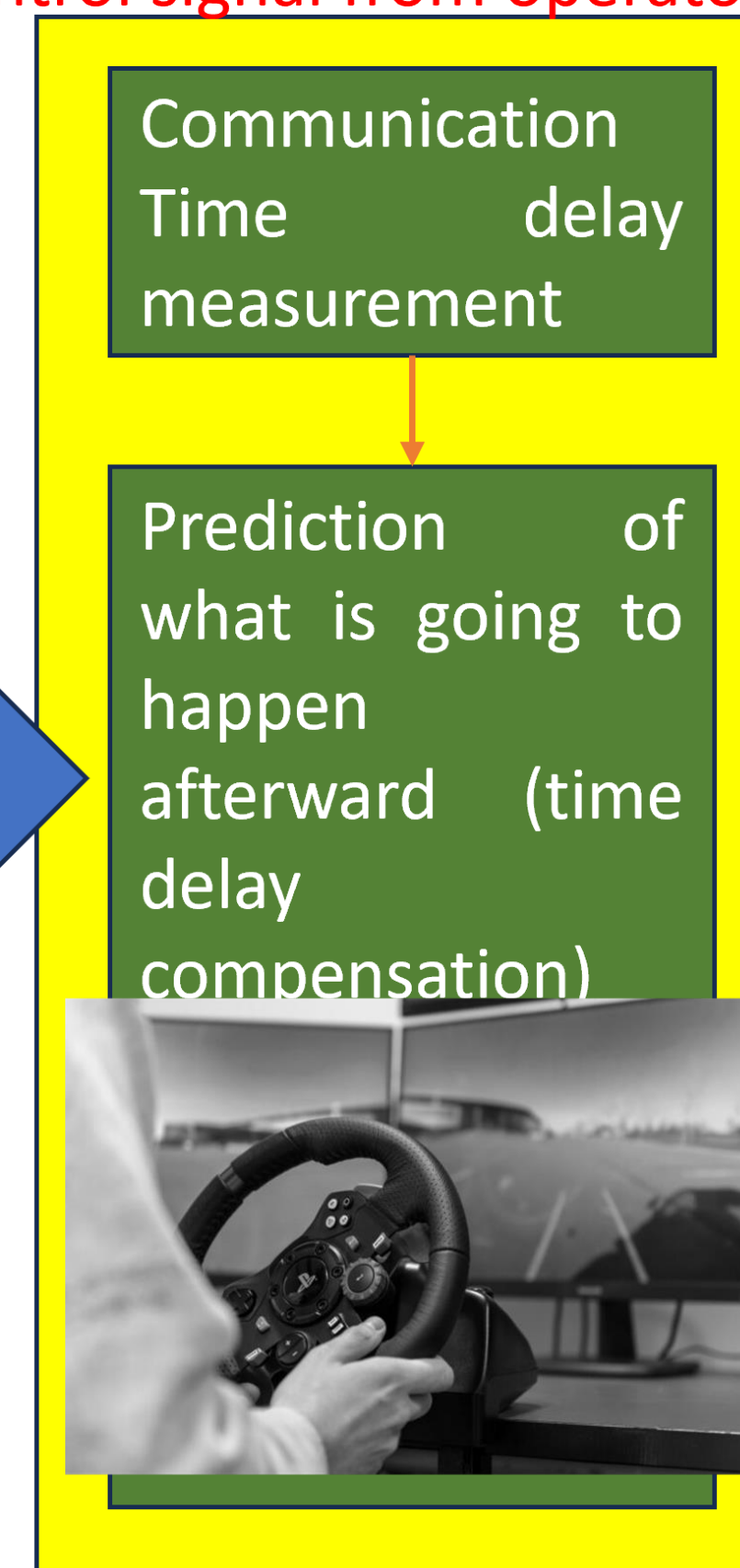
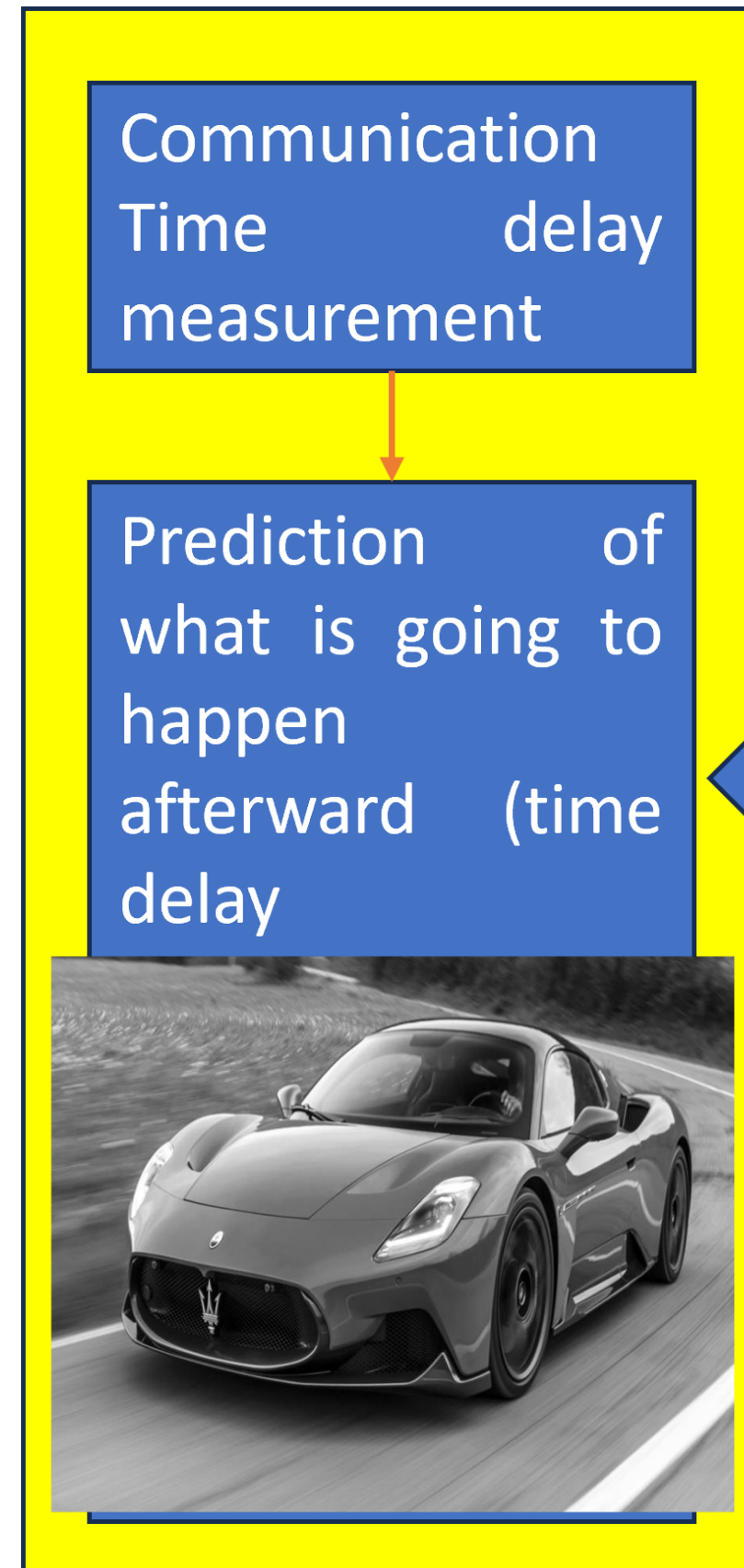
AI model for time-series prediction  
(control signal from operators)





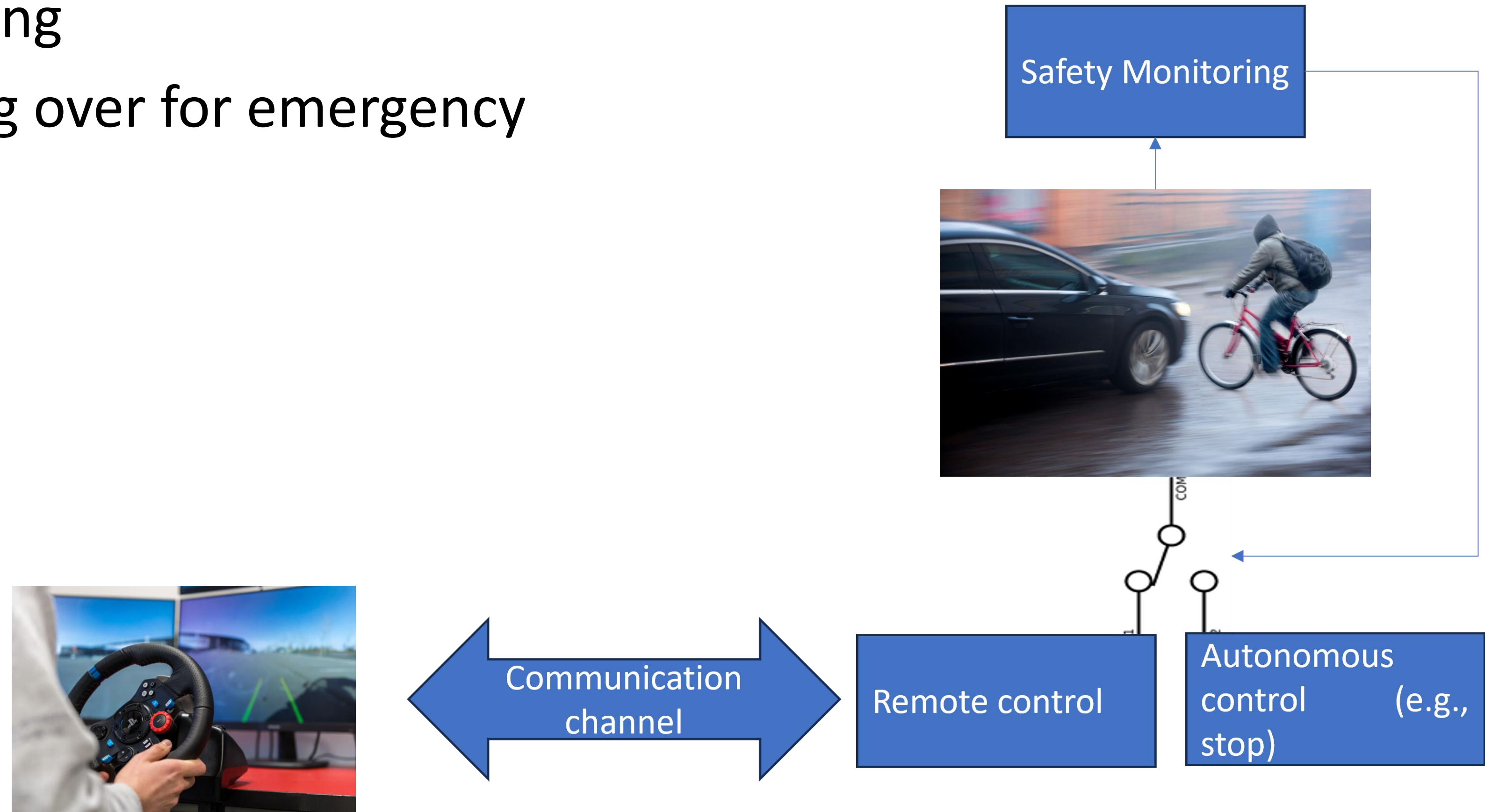
# Our Idea 1. Online Learning and Prediction

AI model for time-series prediction  
(control signal from operators)



## Our Idea 2. Dedicated Safety Layer

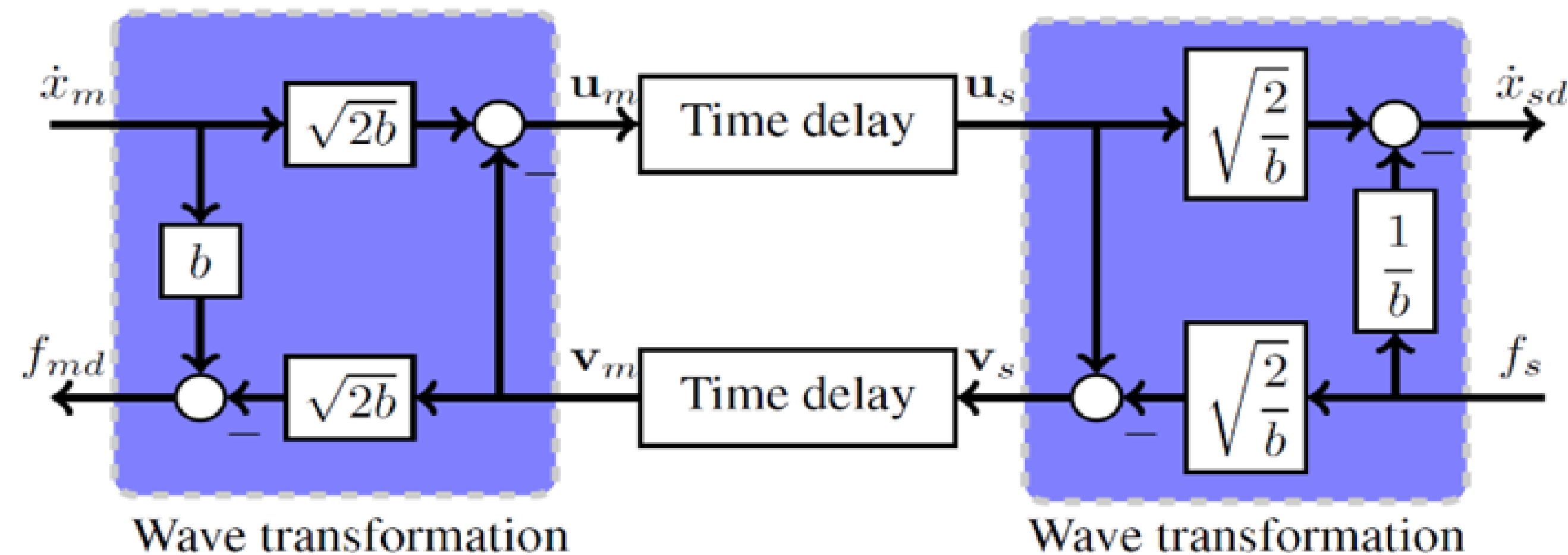
- Safety monitoring
- Edge side taking over for emergency
- Generalization





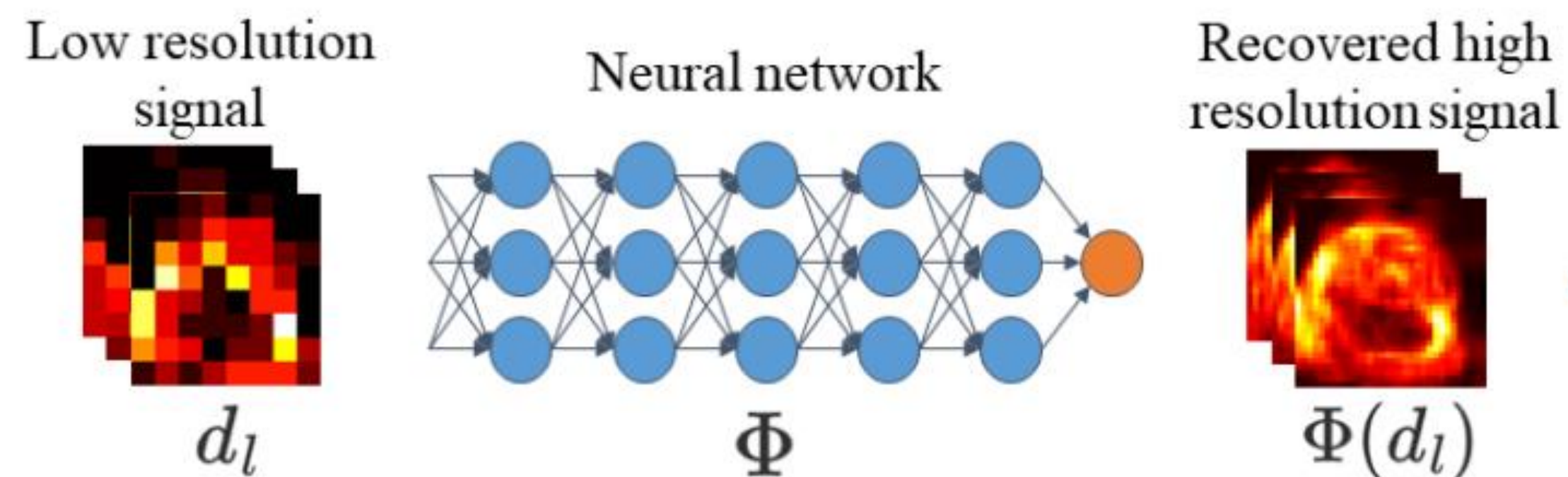
## Our Idea 3. Beyond PID Control

- The time latency in the control loop can trigger instability, making the teleoperated robot out of control for conventional controllers, e.g., PID.
- It has been rigorously proved that passivity-based control using wave transformation is able to reach stable operation with the presence of time delay. We will design the teleoperation system with full consideration of controller stability, rather than simply using PID.



# Our Idea 4. Beyond Nyquist Sampling: High Resolution and High Sampling Frequency Reconstruction

- Intuitively, we can adaptively trade the signal quality for less time latency. For example, when communication quality degrades, we can reduce the signal resolution, and the signal sample rate. But conventionally, we just use the low-quality data directly.
- We can recover high resolution signals based on low resolution ones inspired by works on high resolution re-construction;
- We can even recover high-frequency data from low-sampling frequency ones, even for those under Nyquist sampling frequency, as hinted by recent works on compressive sensing.



(a) Expensive sensing-compression and remote decompression.



(b) Low cost compressed sensing and remote reconstruction.



# Partners Looking

- If you are from robotics community: We are providing a framework to make remote operation, remote surgery, remote driving, safe and under control. This will bring **many potential applications in robotics**.
- If you are from communication community: We are expanding wired/wireless communication to the **new dimension of controlling**, which is a new business terrain

# Conclusion

- Teleoperation=Remote sensing + Remote Control. For remote sensing, time latency might only degrade quality, but for teleoperation, it might trigger **instability**.
- This proposal aims provide a **systematic solution** to enable existing Internet/5G for teleoperation **with safety and stability guaranteed** and quality improved.
- We are **not re-inventing communication network**. We are bringing our domain knowledge on control, robotics and AI to empower existing communication system, so that it can comes into robotics, without introducing issues robotists worry about. We want to help communication service provider to break barriers between robotics and communications and smoothly walk into teleoperation area.



# Contact Info

For more information and for interest to participate please contact:



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Presentation available via:

