1st LOGBOOK (2025-10-31)

1. Select the exact topic that I will work on

There are six available topics according to my superior:

1. Energy-Efficient Communication Strategies for Distributed Agents Investigate how to minimize communication energy consumption without compromising information reliability in distributed agent networks.
2. Time-Triggered vs. Event-Triggered Communication in Control Systems Analyze the effectiveness of time-based versus event-based communication schemes in control performance for autonomous agents.
3. Scalable Control Algorithms for Large Agent Populations Develop control algorithms specifically optimized for scalability in large multi-agent environments with minimal communication overhead.
4. Impact of Communication Delay on Distributed Control Stability Examine how various levels of communication delay affect control system stability and propose mitigation strategies.
5. Priority-Based Communication Scheduling in Multi-Agent Systems Design a scheduling mechanism where agents prioritize messages based on control-critical information.
6. Information Compression Techniques for Control Data Exchange Explore data compression methods that maintain control accuracy while reducing communication load.
7. Fault-Tolerant Control under Partial Communication Loss Develop methods for maintaining control objectives even when some agents lose the ability to communicate.
8. AI Implications of Communication-Control Integration Investigate potential AI methods for joint communication-control mechanisms and propose design guidelines.

In the beginning, I conduct researches on all eight topics by searching information of relative books and papers, I found that the field that I am most interested and confident in is about compression

algorithms. Compared with other choices, I have learned some basic principles of information theory and compression algorithms. And I am also engaged in designing a new open-source library of data compression in distributed control system. In conclusion, topic No.6 is the most suitable for me after preliminary investigation.

2. Early stage research

After selecting *Information Compression Techniques for Control Data Exchange* as my primary research topic, I started with a thorough literature review on existing compression methods applied in distributed control and communication systems. The early research mainly focuses on three aspects:

1. Foundational Understanding:
   I reviewed classical compression algorithms, including entropy coding (Huffman, Arithmetic), transform coding, and lightweight lossless algorithms like LZ77/LZ4, to understand their computational complexity and suitability for real-time control environments. In addition, I studied rate-distortion theory and its relevance to maintaining control accuracy under lossy compression.
2. Application in Control and Communication Systems:
   Research papers on event-triggered communication and data-efficient control were analyzed to understand how information reduction can influence control stability and delay tolerance. I also examined recent works integrating compression with networked control systems (NCS) and edge computing frameworks.
3. Preliminary Experiments and Observations:
   Using MATLAB and Python, I conducted initial experiments to compare the performance of different lightweight compression schemes (e.g., LZ4, Snappy, zlib) in transmitting control data. Results show that high compression ratios often increase latency, indicating a trade-off between communication efficiency

and real-time response — an essential direction for further exploration.

3. Determine my further working plans

Based on the early-stage research, I have outlined several next steps for my future work:

- October,2025

Select and analysis the topic and finish the primitive report

- November,2025

Analyze relative papers and learn deeply about the relevant study.

- December,2025

Attempt to optimize existing methods and manage to achieve satisfying results

- January,2025–June 2025

Writing project report while implement my theoretical research