Weekly Progress Report
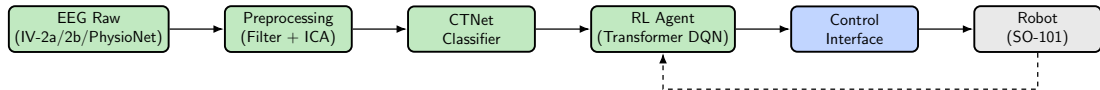## Week of Feb 11: PhysioNet Integration & 3-Dataset RL Control

Student ID: 11314389

BCI Control System Project

February 11, 2026

Legend:

- 🟩 Completed
- 🟦 In Progress
- 🟥 This Week's Focus
- ⬜ Pending

This Week's Goals

1 Integrate Third Dataset: PhysioNet EEGMMIDB
- 109 subjects, 64 channels, 160 Hz
- Left/right hand motor imagery tasks

2 CTNet Classification Test on PhysioNet
- Validate classification performance on new dataset

3 3-Dataset RL Control Comparison
- IV-2a (22ch, 4-class) vs IV-2b (3ch, 2-class) vs PhysioNet (64ch, 2-class)
- Evaluate control reach rate and trajectory smoothness

Methods: PhysioNet Dataset Integration

PhysioNet EEG Motor Movement/Imagery Dataset

- **Source:** `https://physionet.org/content/eegmmidb/1.0.0/`
- **Subjects:** 109 (vs 9 in IV-2a/2b)
- **Channels:** 64 (10-10 system)
- **Tasks:** Real/imagined left-right hand, both fists/feet
- **Format:** EDF+ (loaded via MNE-Python)

Data Pipeline:

1. Download per-subject EDF files (supports partial download)
2. Load with MNE, extract motor imagery runs (4, 8, 12)
3. Apply 8-30 Hz bandpass filter
4. Split train/test (80/20)

Results: CTNet Classification (3 Subjects)

Dataset	Channels	Classes	Accuracy
IV-2a	22	4	63.19%
IV-2b	3	2	65.64%
PhysioNet	**64**	**2**	**70.37%**

Observations:

- PhysioNet achieves highest classification accuracy (70.37%)
- 64-channel montage provides richer spatial information
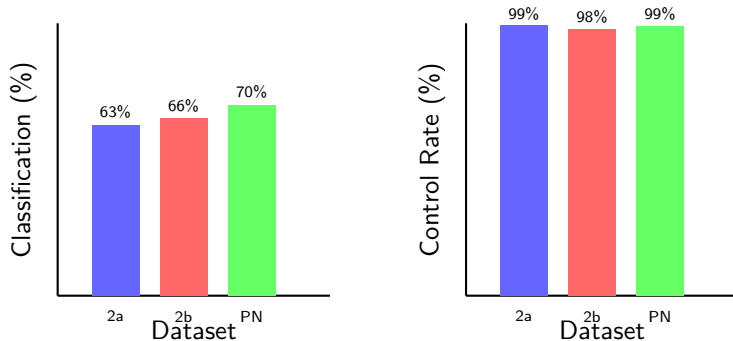- Binary classification (L/R) is easier than 4-class

Results: RL Control Performance

Dataset	Classification	Control Rate	Smoothness
IV-2a	63.19%	**99.33%**	0.700
IV-2b	65.64%	**98.00%**	0.672
PhysioNet	70.37%	**99.00%**	0.681

Key Finding:

- **RL control achieves 98-99% reach rate across ALL datasets!**
- Classification accuracy $\neq$ Control success
- RL agent compensates for classification errors via temporal integration
- Consistent trajectory smoothness ($\sim$0.68-0.70)

Results: 3-Dataset Comparison Visualization

Conclusion: RL control is robust across all three datasets with diverse characteristics!

Challenges & Solutions

Challenges:

- GigaScience dataset too large (226 GB)
- Different data formats (MAT vs EDF)
- PhysioNet label encoding differs

Solutions:

- Switched to PhysioNet (3.4 GB, per-subject download)
- Created unified loader with MNE
- Auto-detect label range in classifier

Code Structure:

- `download_physionet.py` - Download per-subject data
- `physionet_loader.py` - Load and preprocess EDF files
- `rl_control_test.py` - Multi-dataset RL testing

Next Steps

1. **Controller/Limiter** (Priority)
   - Add joint limit protection for robotic arm
   - Prevent over-extension and collisions

2. **Smoother + Delay**
   - Reduce high-frequency oscillations in control
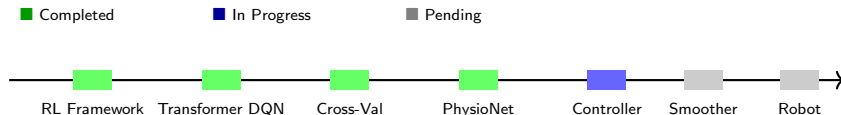   - Add interpolation between commands

3. **Expand Subject Pool**
   - Download more PhysioNet subjects (10-20)
   - Report mean $\pm$ std across larger population

4. **Physical Robot Testing**
   - Deploy to SO-101 arm
   - Real-time EEG $\rightarrow$ control pipeline

Summary:

- Core RL pipeline complete with 3-dataset validation
- Next focus: Hardware interface and control refinement

Thank You!

Questions?