

Automated Recognition and Classification of Trading Cards

Presentation of the Unassisted project

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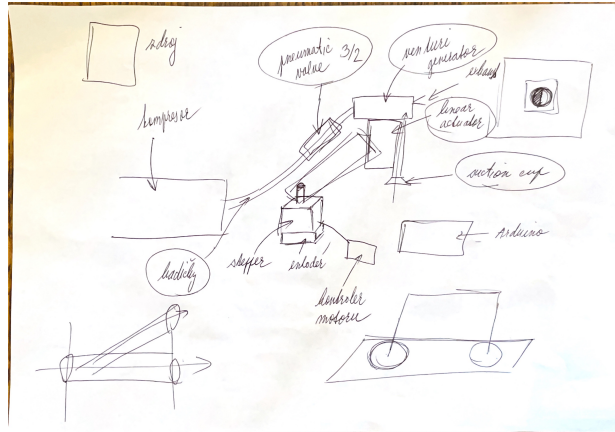
The problem

- ▶ Manual sorting of trading cards (TCG) is time-consuming and prone to errors.
- ▶ Existing commercial solutions (e.g., CardBot) are proprietary and/or expensive.
- ▶ Many different similar cards. MTG has >100k unique cards.

Objectives of the work

- ▶ Software: Recognition pipeline that recognizes cards even from poor-quality photos.
- ▶ Hardware: Affordable and widely available components (Arduino, stepper motors...).
- ▶ The entire project FOSS and well documented so that it can serve as educational material.

- ▶ Focus on affordable components.
- ▶ Vacuum suction cups, stepper motor, pneumatic valve, hall encoder.
- ▶ **Milestone reached:** Precise stepper motor control using rotation encoders feedback loop.



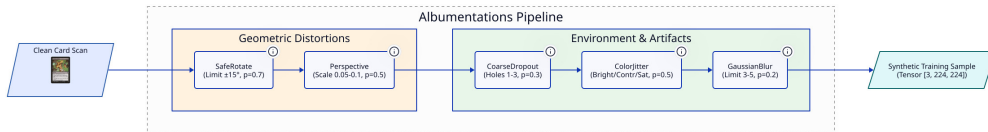
Synthetic Dataset Generation

- ▶ Real-world labeled dataset is non-existent.
- ▶ Scans retrieved via *Scryfall API*.
- ▶ Custom naming convention for human-readability & uniqueness:

```
filename = edition_collectorNumber_name-UUID.png  
zen_21_kor-outfitter-00006596-1166-4a79-8443-ca9f82e6db4e.png
```

Bridge the Domain Gap

- ▶ Heavy augmentation pipeline required to match camera output.
- ▶ **Geometric:** Random perspective, rotation.
- ▶ **Photometric:** Blur, noise, lighting conditions, partial occlusions.

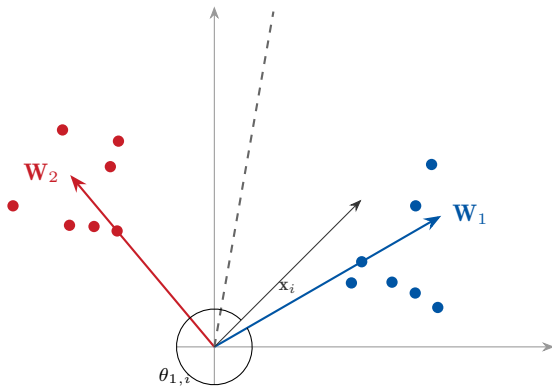


Limitations of Standard Softmax

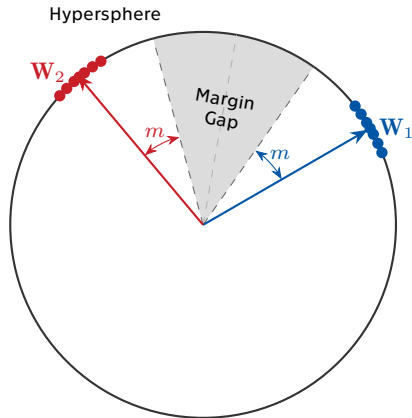
- ▶ Huge number of classes (10^5+) \rightarrow computationally expensive.
- ▶ Open-set problem: New cards are released frequently.

Metric Learning Approach (ArcFace)

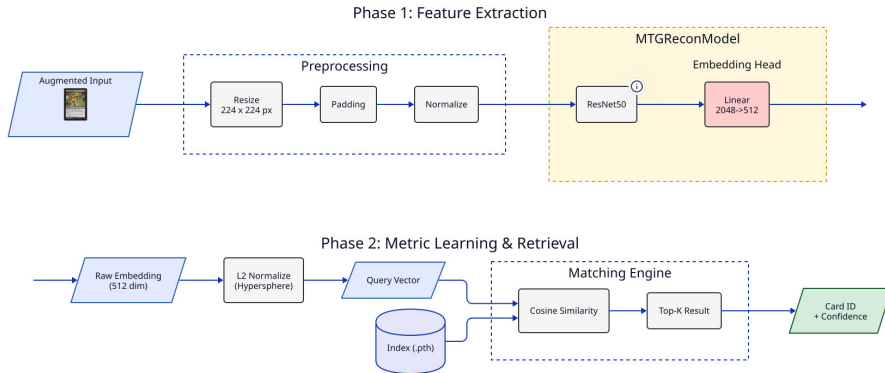
- ▶ Learning a mapping to a hypersphere embedding space.
- ▶ Intra-class **compactness**. Images of the same card are pulled together.
- ▶ Intra-class **separability**. Different cards are pushed apart.
- ▶ Inference via **Cosine Similarity** (Nearest Neighbor).



(a) Standard Softmax Loss



(b) ArcFace Loss



Summary

- ▶ Basic HW control operational.
- ▶ Recognition pipeline implemented (Synthetic Data + ArcFace).
- ▶ Support for MultiGPU training.

Next Steps

- ▶ Hyperparameter sweep (*Weights & Biases*).
- ▶ Finalize mechanical construction.
- ▶ Full integration of the recognition module with the robotic control.
- ▶ Final evaluation on a physical test set.