Master’s thesis on the topic of

# “Continual Learning Method for Image Classification in Computer Vision”

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# Outline

- Continual Learning
- Parking Lot Occupancy Detection
- Baseline Model
- Reproduction
- Results
- Conclusion

# Continual Learning

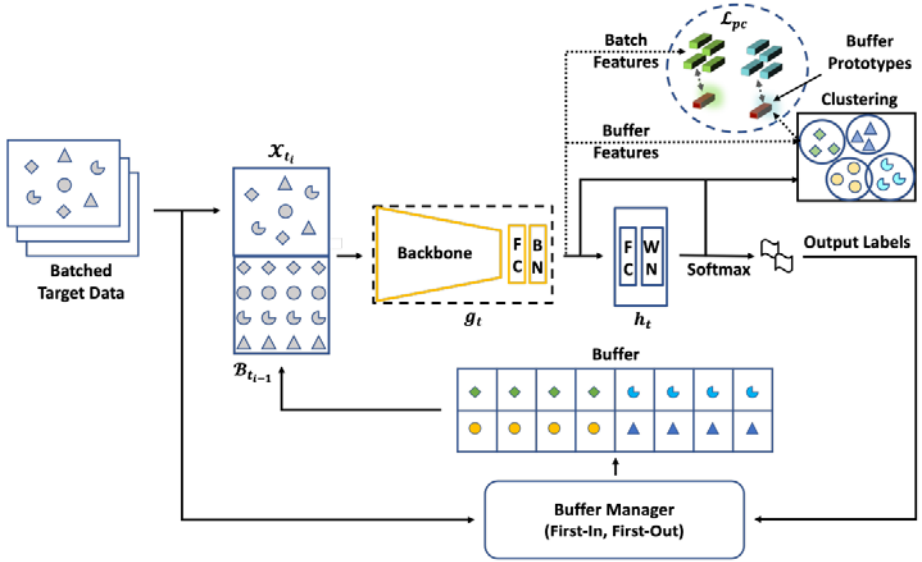
- For decades, attempts have been made to use AI to automate difficult tasks.
- One feature of human intelligence has still been difficult to reproduce using AI – lifelong learning.
- Continual Learning (CL) is a set of approaches within ML that aims to address this limitation.
- Why can our models not learn from their production experience and improve further?

# Parking Lot Occupancy Detection

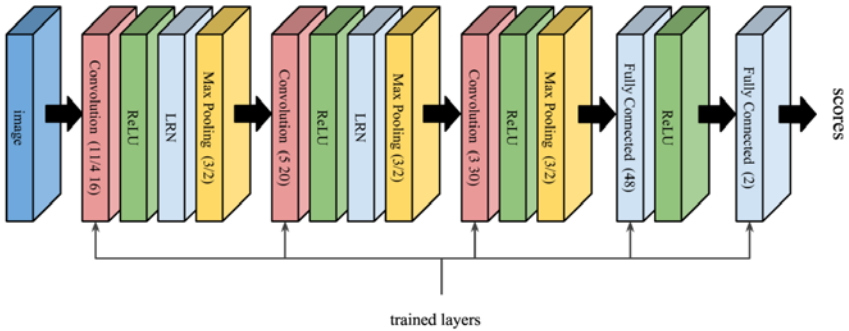
- Binary classification problem, with an endless stream of input data in the form of video camera feed.
- A rather simple problem in the field of ML, but is a perfect use case for CL.
- An amazing comprehensive survey by de Almeida et. al. covers public datasets for this problem, and lists reproducible and unbiased state-of-the-art solutions.

# How it can be improved with CL?

- The UCL-GV method was proposed by Taufique et. al. that performs Unsupervised Domain Adaptation in gradually varying domains.
- This can allow us to tackle gradually changing light conditions, weather changes, and more long-term seasonal changes in the input data.



# Baseline model




- The baseline model was chosen to be mAlexNet by Amato et. al.
- Very simple, yet achieves excellent results.
- Well documented, with publicly available source code.
- Can be combined with UCL-GV in an attempt to improve its performance in a gradually varying domain scenario.

# Reproduction

- After re-implementing the model, experiments have been performed to verify that results can be achieved that are similar to the ones reported in the original paper.
- Most experiments differ from the original by no more than 5%, even outperforming the original model in some cases.

| Method | Train DS / split | Test DS / split | Accuracy | AUC |
|---|---|---|---|---|
| Reproduced | CNRPark / Odd | CNRPark / Even | 91.43% | 0.97 |
| Original | CNRPark / Odd | CNRPark / Even | 90.13% | 0.94 |
| Reproduced | CNRPark / Even | CNRPark / Odd | 91.5% | 0.97 |
| Original | CNRPark / Even | CNRPark / Odd | 90.71% | 0.92 |
| Reproduced | CNRPark / All | CNRParkEXT / Test | 93.64% | 0.98 |
| Original | CNRPark / All | CNRParkEXT / Test | 93.52% | 0.98 |
| Reproduced | CNRPark / All | PKLot / TwoDays | 85.08% | 0.93 |
| Original | CNRPark / All | PKLot / TwoDays | 90.38% | 0.99 |
| Reproduced | PKLot / Train | CNRParkEXT / Test | 74.77% | 0.85 |
| Original | PKLot / Train | CNRParkEXT / Test | 83.83% | 0.91 |
| Reproduced | PKLot / Train | PKLot / Test | 84.29% | 0.97 |
| Original | PKLot / Train | PKLot / Test | 98.07% | 0.99 |
| Reproduced | CNRParkEXT / Cam1 | CNRParkEXT / Cam2 | 95.34% | 0.99 |
| Original | CNRParkEXT / Cam1 | CNRParkEXT / Cam2 | 95% | - |

# Results

- Experiments have been modeled to feed images in the order they were taken.
- Experiment results consistently show that the model that is enhanced with CL techniques is able to consistently achieve better accuracy on a classical ML scenario.

| Method | Train DS / split | Test DS / split | Accuracy |
|---|---|---|---|
| mAlexNet | CNRParkEXT / All | CNRPark / All | 95.21% |
| mAlexNet+UCL-GV | CNRParkEXT / All | CNRPark / All | 95.73% |
| mAlexNet | CNRParkEXT / Cam1-8 | CNRParkEXT / Cam9 | 96.01% |
| mAlexNet+UCL-GV | CNRParkEXT / Cam1-8 | CNRParkEXT / Cam9 | 96.85% |
| mAlexNet | PKLot / TwoDays | PKLot / NotTwoDays | 91.74% |
| mAlexNet+UCL-GV | PKLot / TwoDays | PKLot / NotTwoDays | 92.11% |

# Conclusion

- The paper attempts to view the paradigm of Continual Learning from a completely new perspective.
- CL methodologies have been successfully utilized to achieve better performance on traditional problems, as opposed to solving new types of problems.
- Even “mostly solved” ML problems can be further improved by introducing contemporary CL methods.
- Future work may include attempts to improve more classical ML problems using this technique.

# Thank you for your attention!