ART AND MACHINE LEARNING
CMU 2019 SPRING
FINAL PROJECT

Out of Place

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DESCRIPTION

Using low rank matrix factorization, we are able to take videos with still backgrounds and extract only the moving foreground. With this, we are able to take videos of animals out of their habitat and put them somewhere they may find themselves as global warming and modernization sweeps the planet. In the same way, we can also take videos of animals that already are away from home, and try to put them back in their original habitat.

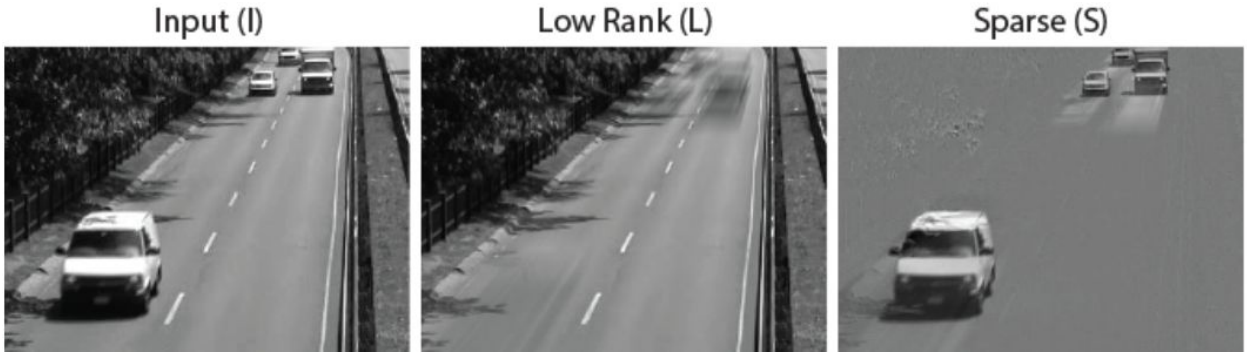
Concept:

"The evidence is incontrovertible: Global warming is occurring. If no mitigating actions are taken, significant disruptions in the Earth's physical and ecological systems, social systems, security and human health are likely to occur," says the American Physical Society in 2007. Over 10 years later, this message is only more harrowing. Virtually all life on our planet today has to adapt to us. Our project seeks to show the stark discomfort in how animal habitats have changed and will continue to change.

Technique:

Low-Rank Matrix Factorization

Matrix factorization is used for identifying latent features between datasets. Uncovering these features allows us to obtain a compressed representation of the datasets. Factoring the original matrices into low-rank matrices enables us to perform methods such as dimension reducing, clustering, and matrix completion. This was our initial method for background subtraction - splitting the video into a low-rank component (background) and a sparse component (foreground). An example on a single frame of a random video about a car on a street is shown below:



However, this method takes a huge amount of time to run on high-quality RGB videos, as well as sometimes produced incoherent results, so we also looked into other approaches that were more realistic, but also fit our concept.

Gaussian-Mixture Model

Gaussian-Mixture Model is used for background subtraction. It uses probabilities to predict whether the neighboring pixels belong to the same ground as the current pixel. We tried three

methods based on this concept: Mixture of Gaussian (MOG), Improved Mixture of Gaussian (MOG2), and Background Subtraction GMG. We also try to vary the parameters with these algorithms and concluded that MOG provides the most acceptable results among the three methods.
We then use the MOG method to obtained the mask and the foreground. The mask is simply the silhouette of the target and the foreground is the extracted result from applying the mask to the original video.

Process:
We started off with experimenting with low-rank matrix factorization for background subtraction. We wanted to create art using "natural" ways i.e. simple math operations. However, the bar for data/source for low-rank matrix factorization was very high. It requires an almost steady background with foreground objects moving constantly in order to get a good result. Thus, we fall back to our second option of using another simple math operation which is the Gaussian-Mixture Model for background subtraction. The result foreground was broken. However, we think this result fits our concept that no natural ways would remove animals from their natural habitat. Only humans could forcefully remove these animals from their home. The broken images of the animals symbolized that they are not what they are anymore once being forced out of their home. For the video, we interchanged between the original video(natural form), the mask and the broken foreground (unnatural form) to express this idea.

Result: Our result compose of two parts. The focus of the first part is giraffe. Giraffe was a common animal that was hardly concerned as endangered. However, recent reports has indicate that the population of giraffe has decreased drastically (40% in the last three decades). Some of the reasons for the decreasing giraffe population includes: loss of habitat due to human activities; illegal hunting; and human-wildlife conflicts. Thus the first part of our video symbolized the extraction of giraffe from their natural habitat will eventually force them to go extinct.
The second part of our result is the reverse of the first part. We started off the video with a sea turtle trapped within an aquarium. While it was in the aquarium, audience could hardly see the from and shape of the sea turtle. However, as it moves back to the ocean, its natural habitat, its form became more clear sharp symbolizing the freedom of the sea turtle. Our final video is at https://drive.google.com/open?id=1ax493gg22_4sWQY3bMrv-juW7TD7Eo1g.

Reflection: Our final result was chosen by the methods we discussed above. Here are some of the process documented in (partially failure) examples with a random video from the CMU carnival:

Original Video:
drive.google.com/file/d/1GfP0iLJA-1vZCayJs7ym4ZmPNiI6tcYt/view
Low-rank part (background):
drive.google.com/file/d/10zS1DugVHehOP0XiQTpbTUS11g7FvK5f/view

Sparse component (foreground):
drive.google.com/file/d/1o70_prsbkzAgXW9X4ELfT58RzvitQAXh/view

This is why we chose our final methods as discussed above, to produce the video illustrated in the results section. We think our final result aligns well with our concept that each animal has its own habitat and only humans can forcefully to remove them from their habitat completely.

Related Work and Research:

1. Matrix Factorization Techniques for Recommender Systems (link)
2. Matrix Factorization for Travel Time Estimation in Large Traffic Networks (link)
3. Low-Rank and Sparse Tools for Background Modeling and Subtraction in Videos (link)
4. Low-Rank Matrix Recovery via Convex Optimization (link)
5. An Improved Adaptive Background Mixture Model for Real-Time Tracking with Shadow Detection (link)
6. Improved Adaptive Gaussian Mixture Model for Background Subtraction (link)
7. Visual Tracking of Human Visitors under Variable-Lighting Conditions for a Responsive Audio Art Installation (link)

References:

1. https://github.com/andrewssobral/lrslibrary
2. https://yangjiera.github.io/works/low-rank.pdf
3. https://github.com/groverpr/Linear-Algebra
4. https://docs.opencv.org/3.3.0/db/d5c/tutorial_py_bg_subtraction.html
5. https://explore.org/livecams

Video Sources:

1. Giraffe footage
2. Hunting background
3. Johannesburg background
4. Sea turtle footage
5. Aquarium background
6. Background music

CODE: https://github.com/deepm/artml/tree/master/Final%20Project

RESULT VIDEO:
https://drive.google.com/open?id=1ax493gg22_4sWQY3bMrv-juW7TD7Eo1g

Screenshots of masks and the output