



Gotta Cluster 'Em All

A Study of Pokémon with Unsupervised Learning

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Introduction – Research Question

Grass



Water



Fire



- Pokémon of the same type seem to share a common color palette.

- Can unsupervised learning algorithms identify the color-based intra-type commonalities, and group the images into clusters that matches the pre-assigned type labels?

Introduction – Data Overview

Pokémon Showdown BETA

Home Pokédex Replays Ladder Forum Play

Search Pokémon Moves

Search pokemon OR filter by type,

Sort: Name Types

Abilities HP Atk Def SpAtk SpDef

BST

Generation 1

LC Bulbasaur GRASS POISON

NFE Ivysaur GRASS POISON

UU Venusaur GRASS POISON

Illegal Venusaur-Mega GRASS POISON

AG Venusaur-Gmax GRASS POISON

LC Charmander FIRE

NFE Charmeleon FIRE

PU Charizard FIRE FLYING

Illegal Charizard-Mega-X FIRE DRAGON

Bulbasaur #1 LC

Types: GRASS POISON

Size: 0.7 m, 6.9 kg
Grass Knot: 20

Abilities: Overgrow | Chlorophyll (H)

Base stats:

	min-	min	max	max+
HP: 45		231	294	
Attack: 49	92	134	197	216
Defense: 49	92	134	197	216
Sp. Atk: 65	121	166	229	251
Sp. Def: 65	121	166	229	251
Speed: 45	85	126	189	207
Total: 318				

at level 100

Evolution: Bulbasaur → Ivysaur → Venusaur

Egg groups: Monster, Grass

Gender ratio: 87.5% male, 12.5% female

Past gens

- Pokémon avatars and type info are scrapped from *Pokémon Showdown* with Selenium.
- The raw data set contains 774 Pokémons and 18 unique types.
- Our project focuses on fire, grass, and water type only.

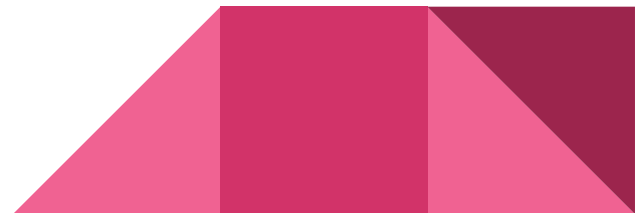
Data Preprocessing – Color Space

- Raw images are 96 by 96 with RGBA color channels.
- Three-channel RGB color space supplemented with a fourth alpha channel that controls for opaqueness.
- We convert raw images from RGBA to RGB format using *opencv*.



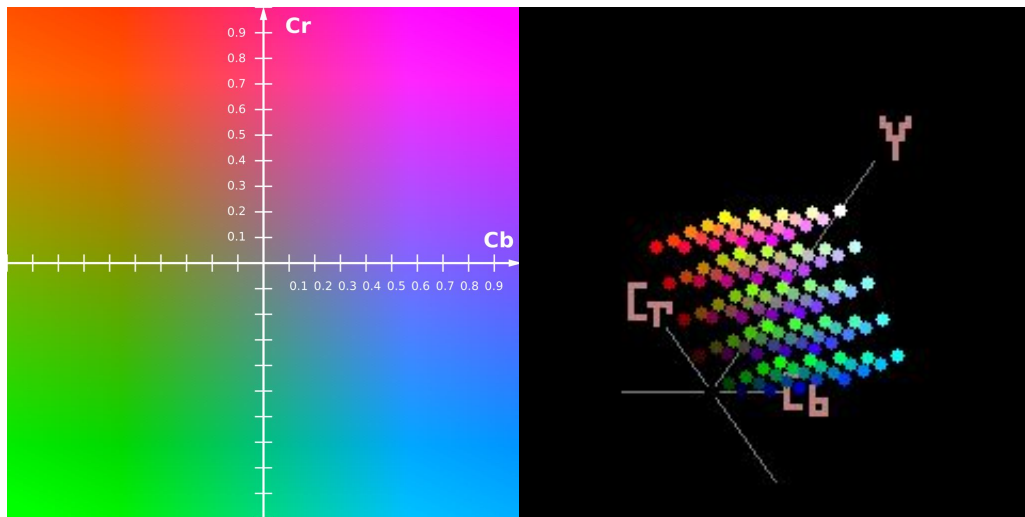
RGBA

Source: Wikipedia



Data Preprocessing – Color Space

- Literature suggests that distance in the RGB space does not translate well into perceived difference.
- YCbCr does a better job in skin detection (Aibinu et al. 2012).
- We use opencv again to transform RGB images to YCbCr images.

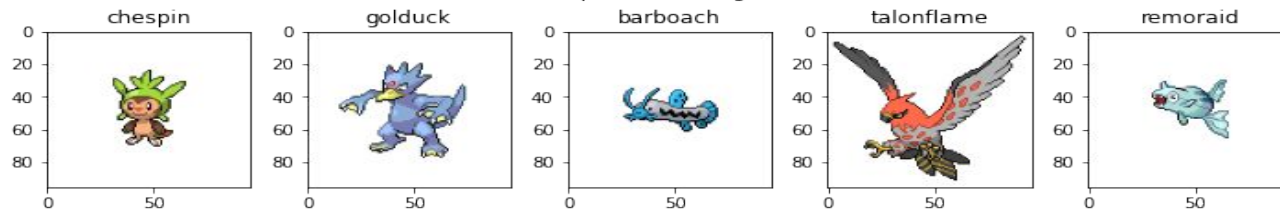


YCbCr

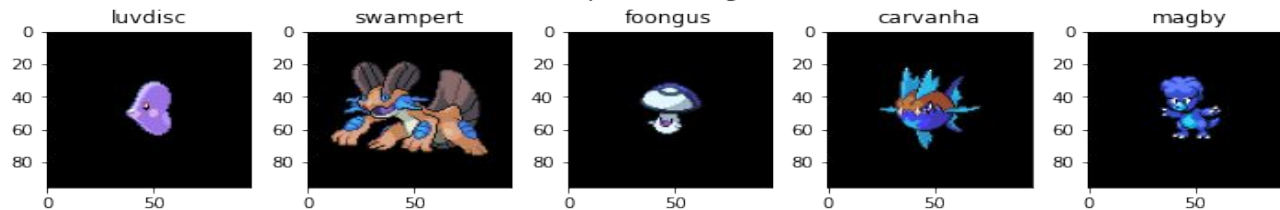
Source: Wikipedia

Data Preprocessing – Color Space

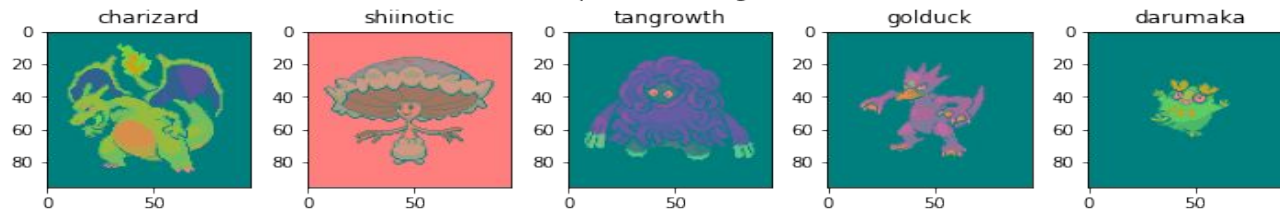
Sample RGBA Images



Sample RGB Images



Sample YCbCr Images



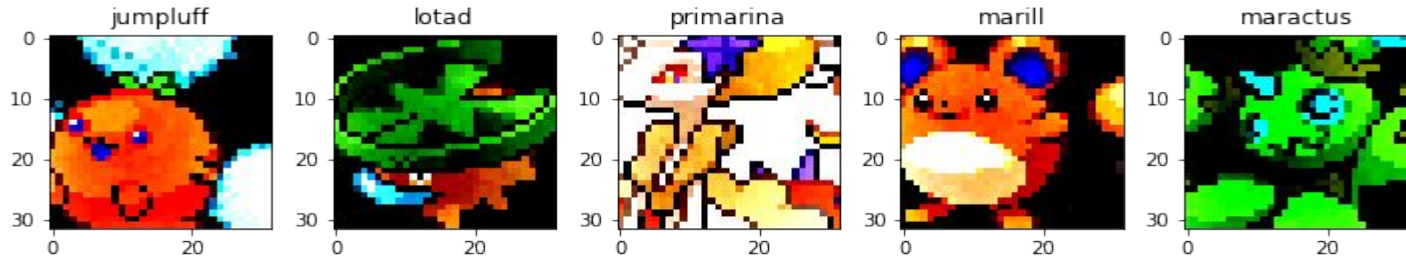
Data Preprocessing – Others

- Size of the avatar in each image varies.
- Resizing won't solve this inconsistency.
- We crop the images and only keep the center 32 by 32 chunk.
- We also normalize the pixel values to zero mean and unit variance.

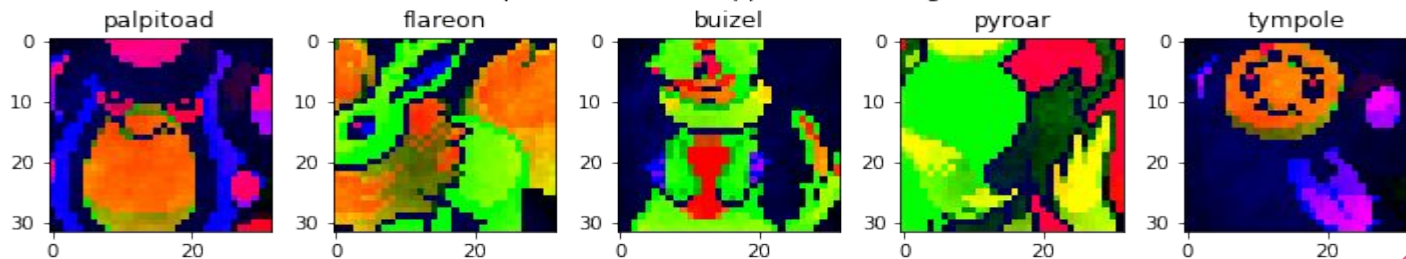


Data Preprocessing – Others

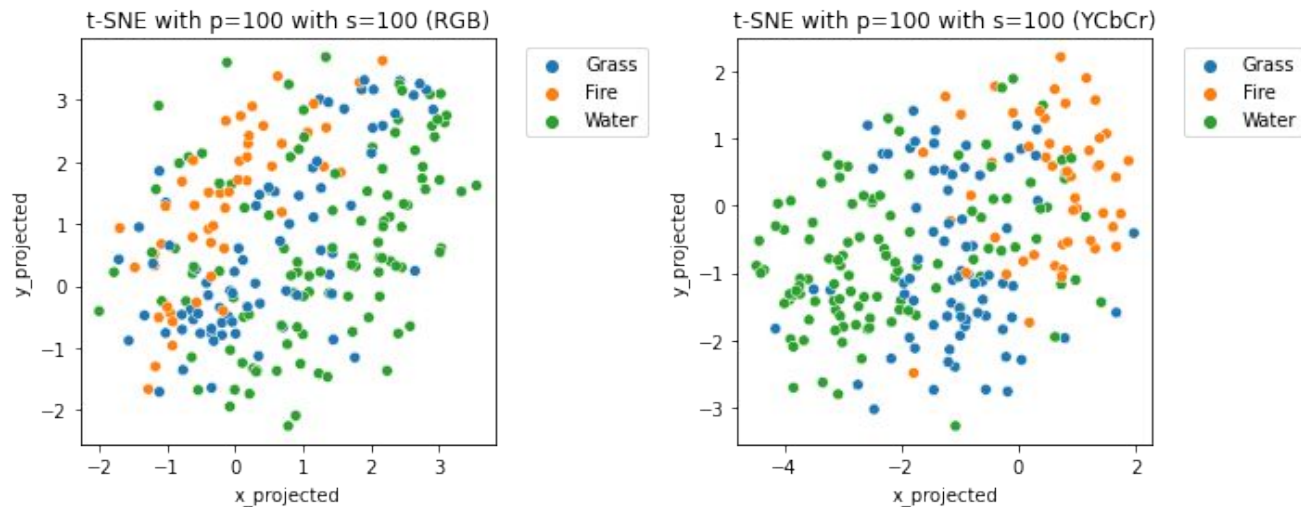
Sample Normalized Cropped RGB Images



Sample Normalized Cropped YCbCr Images



Unsupervised Learning – Clusterability

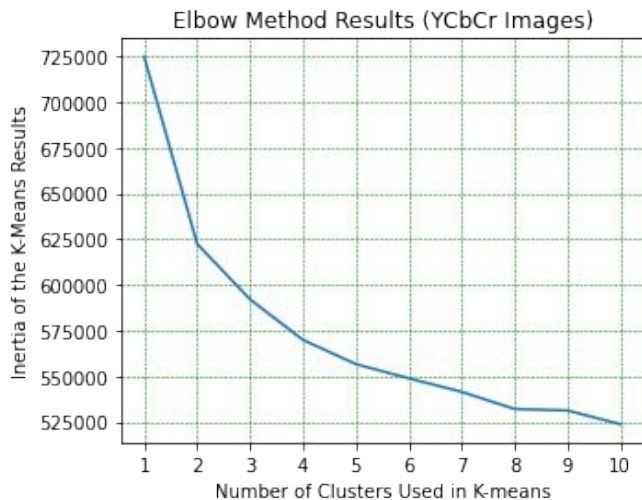
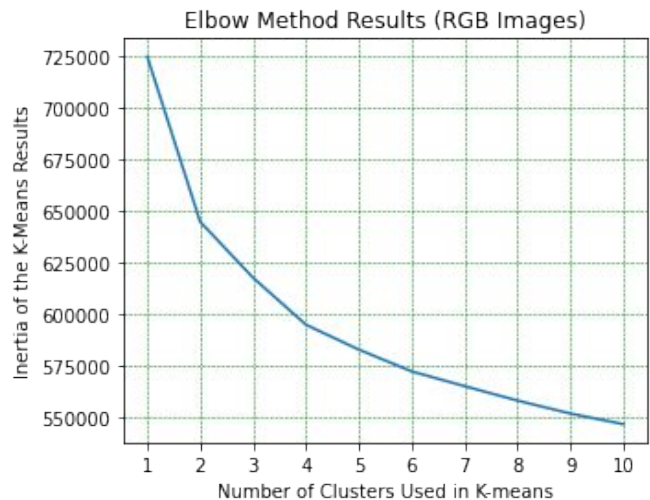


- On the one hand, it is hard to visually detect any patterns without the true labels.
- On the other hand, we can observe some level of grouping for data points with the same label.

K-Means

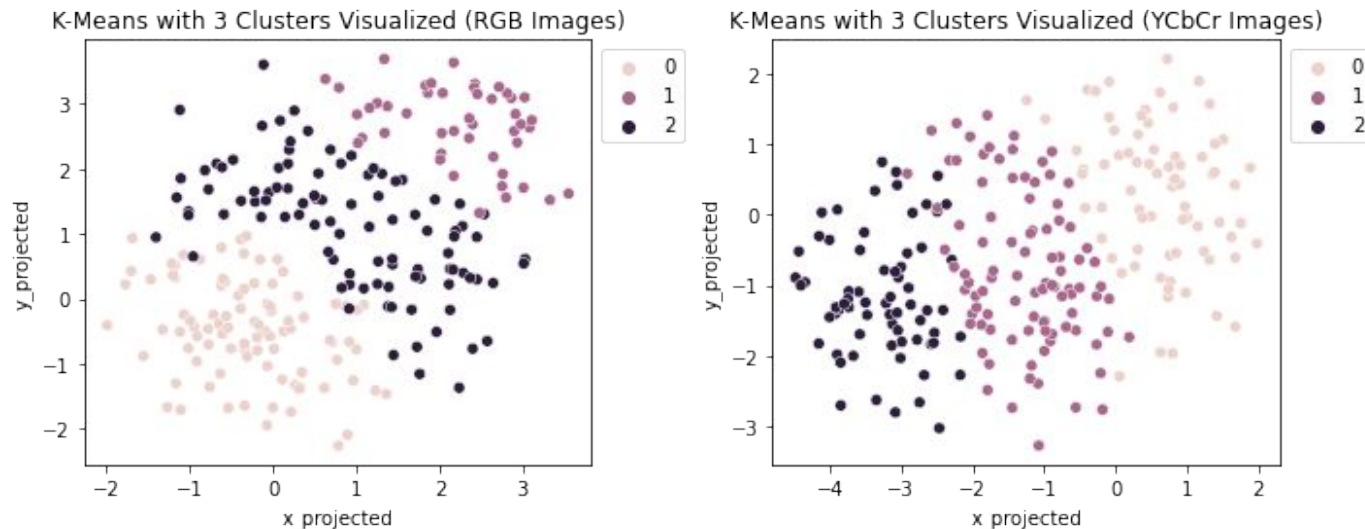
GM

Unsupervised Learning – K-Means



- All attributes are numerical.
- The algorithm is easy to implement without involved parameter tuning.

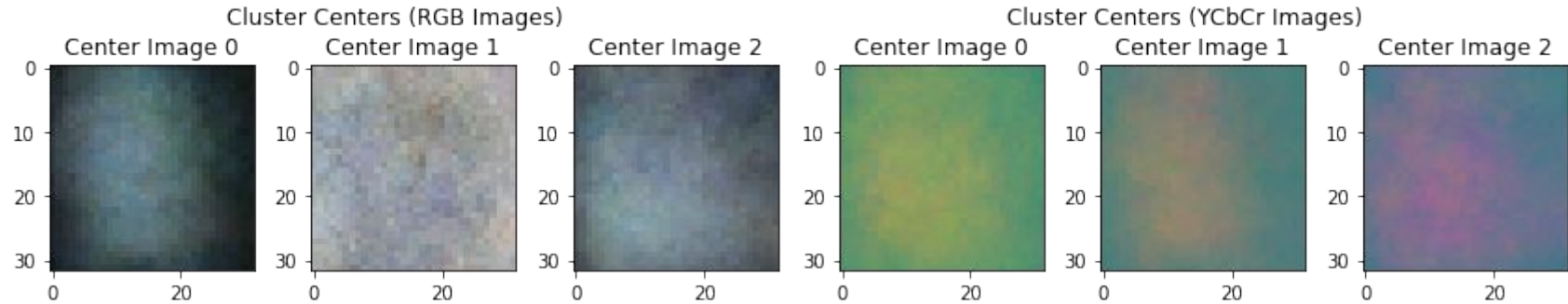
Unsupervised Learning – K-Means



- The algorithm is able to identify 3 clusters that roughly match the true label distribution when the images are in the YCbCr color space.

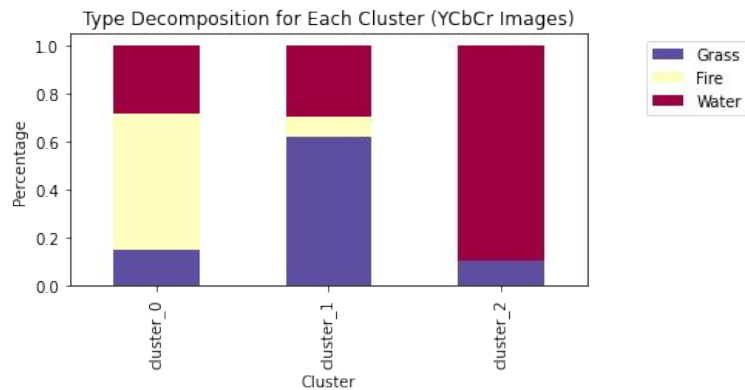
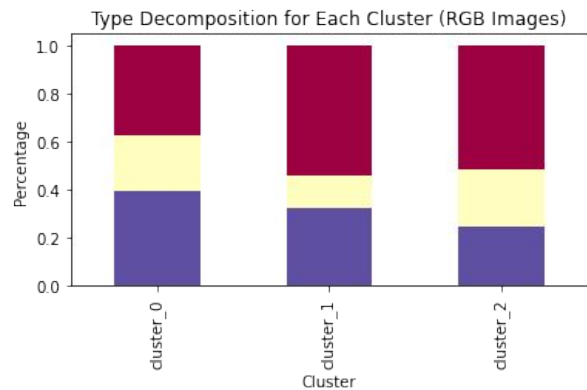
True Labels

Unsupervised Learning – K-Means



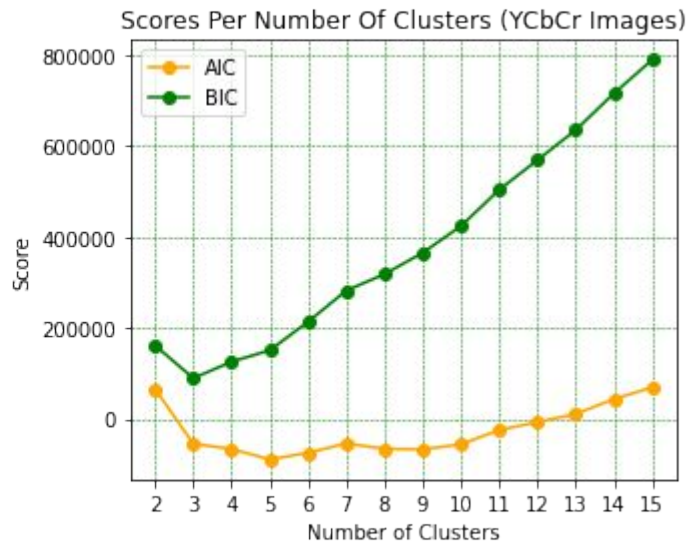
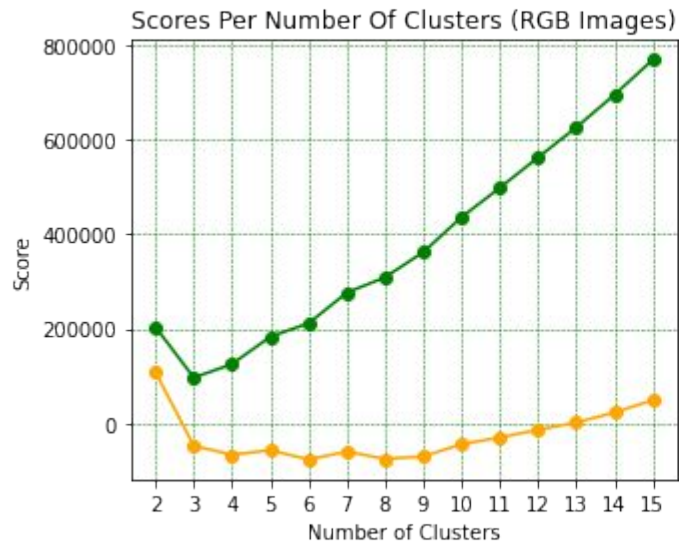
- The cluster separation criterion seems to be color-related when we use YCbCr images.

Unsupervised Learning – K-Means



- We conclude that k-means can recognize the color palette similarities and differences related to Pokémon types when YCbCr images are used.
- If we treat this exercise as a classification task, the accuracy score of YCbCr image based k-means is 0.6822.

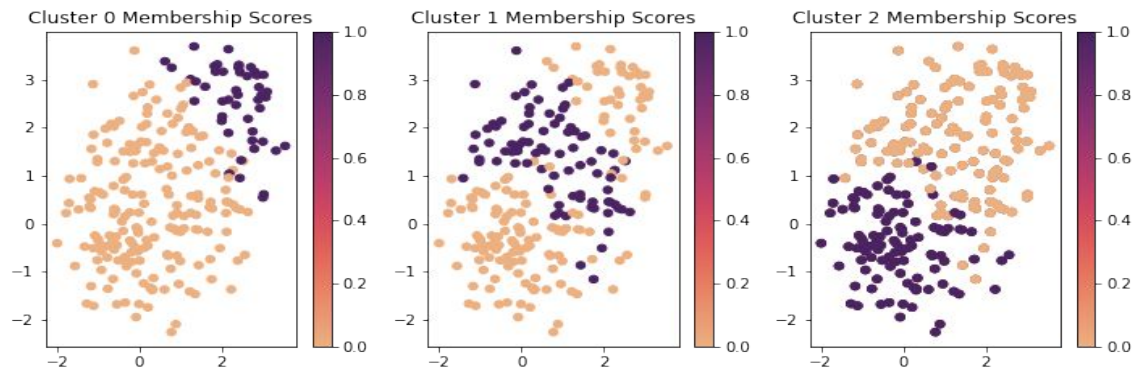
Unsupervised Learning – Gaussian Mixture



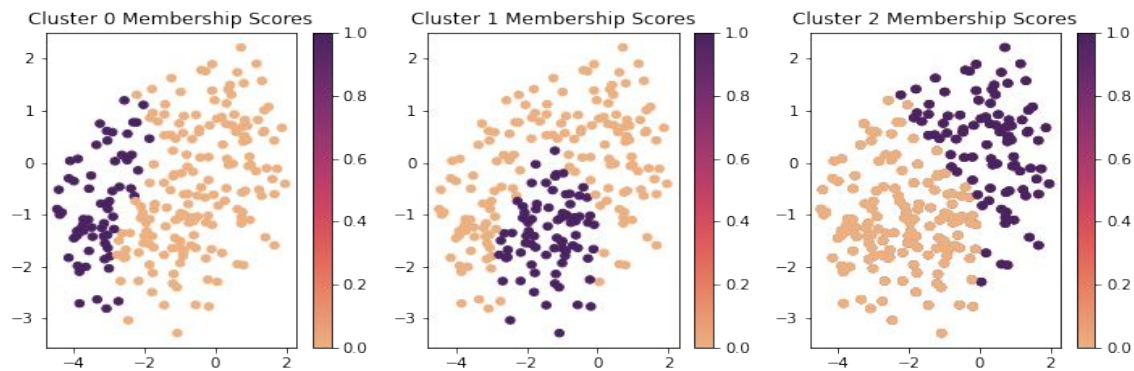
- The pixel value distribution could be multimodal.
- We need flexible decision boundaries.

Unsupervised Learning – Gaussian Mixture

Fuzzy Clustering: 3 Clusters (RGB Images)

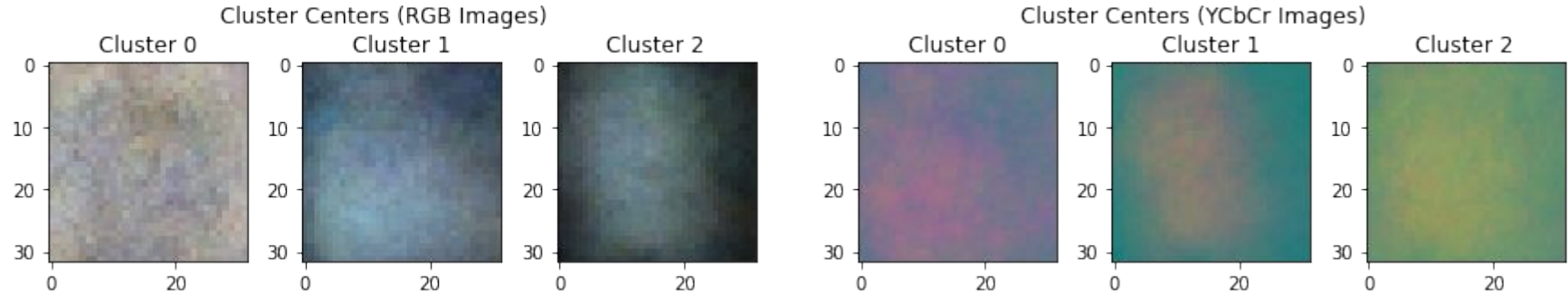


Fuzzy Clustering: 3 Clusters (YCbCr Images)



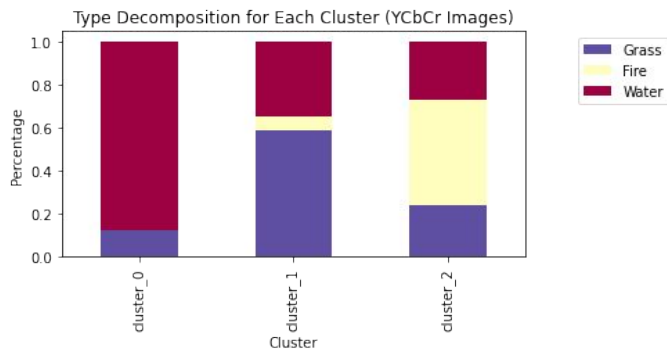
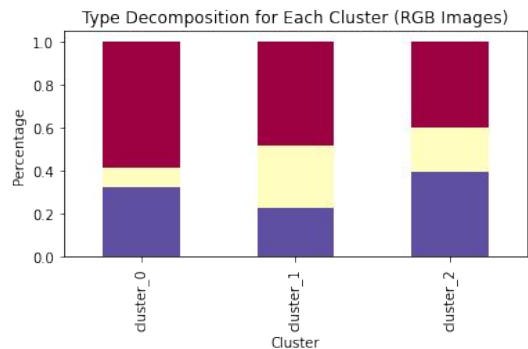
True Labels

Unsupervised Learning – Gaussian Mixture



- Gaussian mixture yields similar cluster centers to k-means.

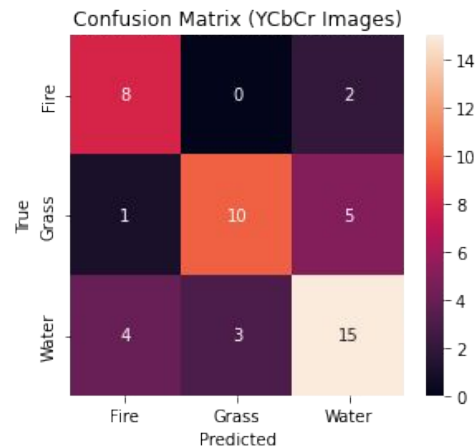
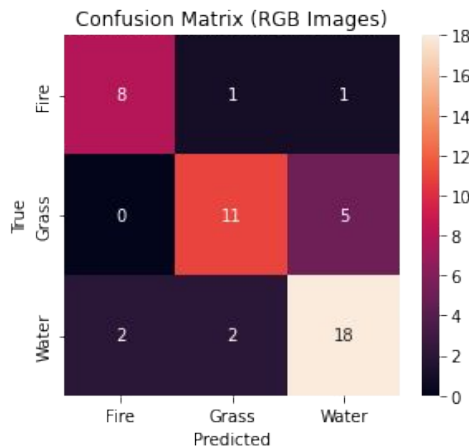
Unsupervised Learning – Gaussian Mixture



- Label decompositions of the clusters with Gaussian mixture model are similar to the ones from k-means.
- Accuracy score when YCbCr images are used is 0.6314.

Supervised Learning – Support Vector Machine

- Uncropped RGB and YCbCr images are used (80-20 train test split).
- RGB images yield better accuracy when the same model is applied.
- Unsupervised learning algorithms can achieve similar performance to support vector machine model.



Deep Learning – Convolutional Neural Network

Layer (type)	Output Shape	Param #
Conv2d-1	[-1, 32, 96, 96]	896
MaxPool2d-2	[-1, 32, 48, 48]	0
Conv2d-3	[-1, 64, 24, 24]	18,496
MaxPool2d-4	[-1, 64, 12, 12]	0
Conv2d-5	[-1, 64, 12, 12]	36,928
MaxPool2d-6	[-1, 64, 6, 6]	0
Linear-7	[-1, 512]	1,180,160
Linear-8	[-1, 3]	1,539

Total params: 1,238,019

Trainable params: 1,238,019

Non-trainable params: 0

Input size (MB): 0.11

Forward/backward pass size (MB): 3.26

Params size (MB): 4.72

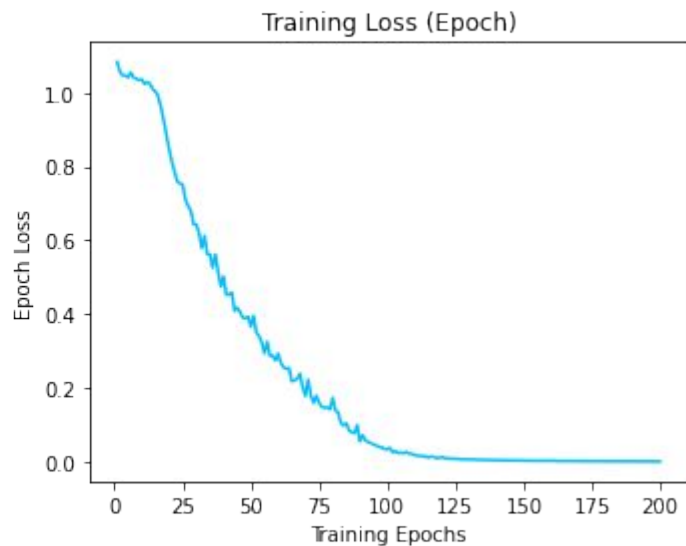
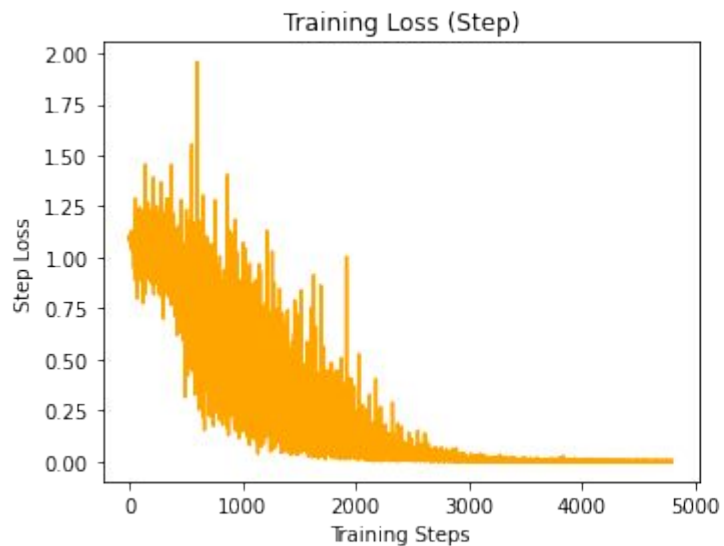
Estimated Total Size (MB): 8.08

Deep Learning – Convolutional Neural Network

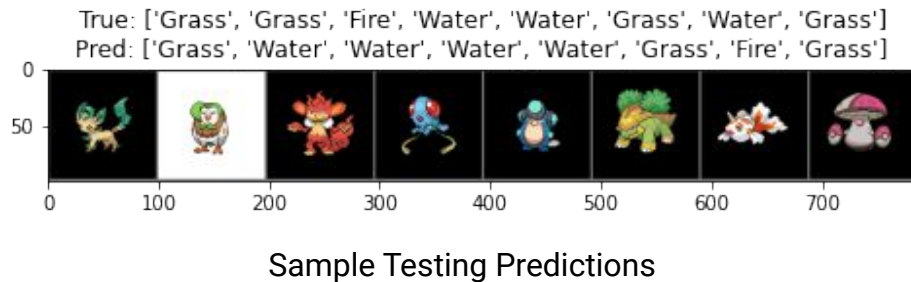
- Like the support vector machine implementation, we split the data (80-20) into training and testing set with balanced label distribution.
- PyTorch automatically convert the images to RGB from RGBA.
- The training is done with batch size of 8, learning rate 0.01, and 200 epochs.



Deep Learning – Convolutional Neural Network



Deep Learning – Convolutional Neural Network



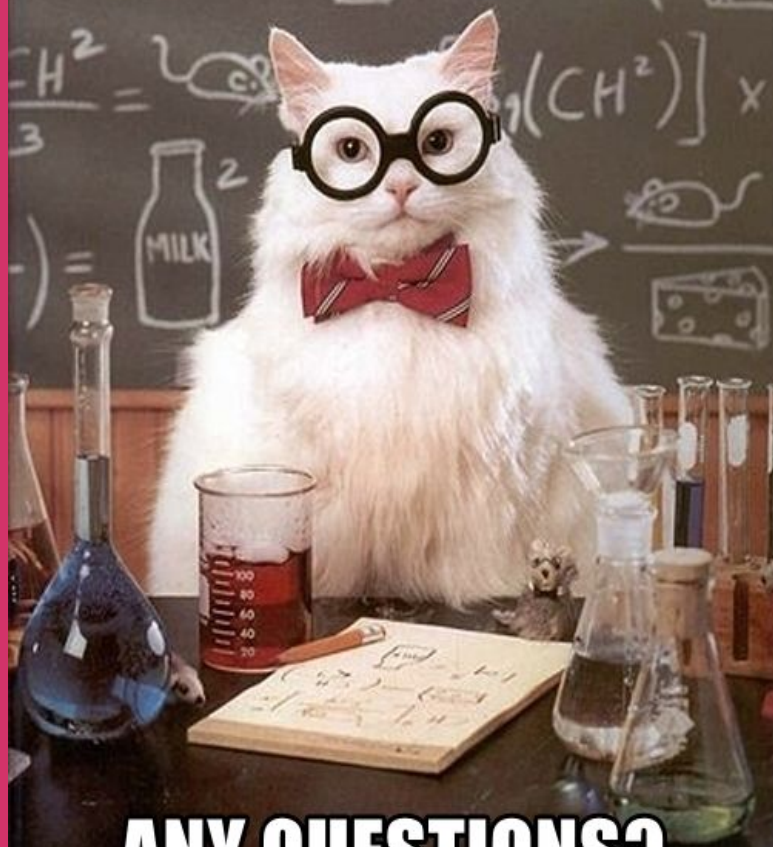
- Testing accuracy with our CNN model is 0.8125.
- While the performance is better than support vector machine, the lead is not significant.

Conclusion

- Pokémon color palettes are indeed correlated with types. And unsupervised learning algorithms can identify the similarities and differences in Pokémon color palettes.
- Unsupervised learning algorithms benefit from using color space that better captures the perceived color difference.
- With proper tuning, unsupervised learning algorithms can achieve performance on par with supervised learning models in classification tasks
- Unsupervised learning can facilitate hidden commonality discovery.



THANK YOU



ANY QUESTIONS?