SI Project Document

Team VII

Name	Section	Bench No.
Essam Wisam	2	2
Mohamed Saad	2	15
Hala Hamdy	2	35
Noran Hany	2	34

Supervised by

Dr. Sandra Wahid

Eng. Amr AbdElBaky

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Introduction

Project Motivation

The motivation behind this project stems from the need to create an automated method that utilizes machine learning and computer vision techniques to accurately determine whether satellite imagery is flooded or not. Furthermore, this project aims to effectively segment all pixels corresponding to flooded regions in the classified images.

Folder Structure

```
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├──DataPreparation
├──FeatureExtraction
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|   ├──Hist
|   ├──Resnet
|   └──Shufflenet
└──ModelPipelines
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    ├──ISODATA
    ├──KMeans
    ├──LogisticRegression
    ├──QDA
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```

Data Preparation

Our data preparation module supported the following:

- Reading the images
- Normalizing the images
- Changing the images to grayscale
- Applying a list of albumentations transformations
- Transposing the images to be either channel-first or channel-last
- Saving the processed images

Feature Extraction

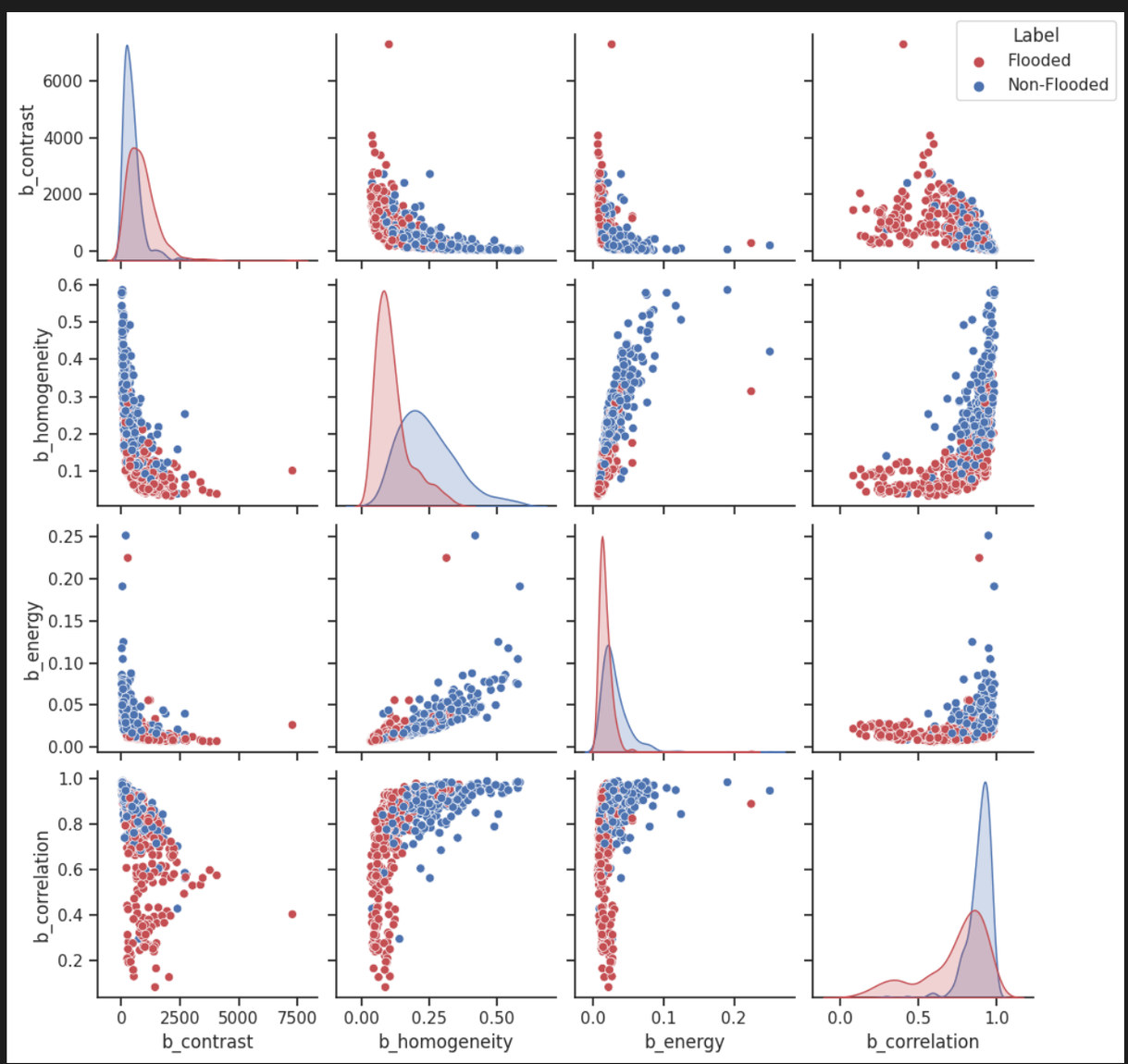
Classical Features

The following were the features considered

- HIST
- GLCM
- LBP
- HOG

GLCM Separability

Assessing the separability of the glcm features:

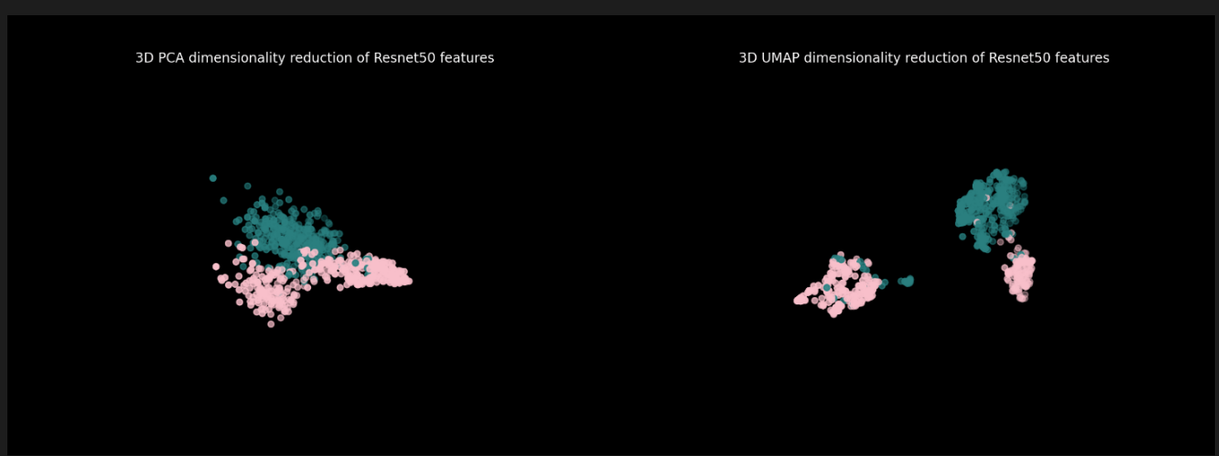


Deep networks as feature extractors

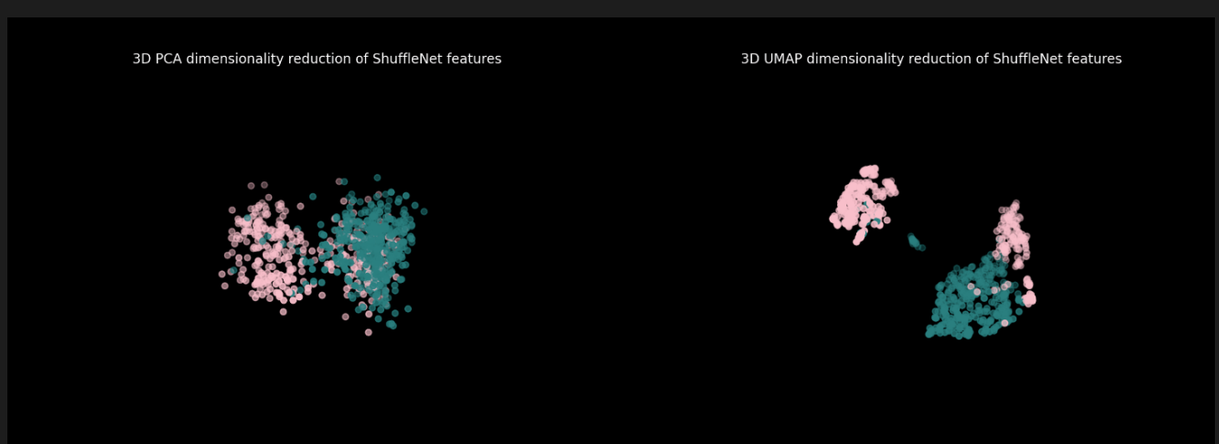
We considered using the following pre trained deep nets versions to extract embeddings from images. For that all layers for such deep nets were considered except the fully connected layers.

- Resnet
- Shufflenet

Resnet Separability



Shufflenet Separability



Models Considered

We've tried each feature of the mentioned above with each of the following models with hyperparameter tuning.

SVM

Deep Features

info				read_data				apply_deep_d			SVC												metrics	
time	date	duration	id	gray	normalize	new_size	saved	transpose	saved	eval	kernel	C	degree	gamma	coef0	shrinking	probability	tol	cache_size	verbose	max_iter	decision_function_shape	break_ties	Accuracy	F1
00:14:52	04/23/23	1.09 min	1	False	True	224	True		True	False	linear	1	3	scale	0.0	True	False	0.001	200	False	-1	ovr	False	0.9891891891891892	0.9891508327468919
21:30:54	05/20/23	19.58 s	2	False	True	224	True	False	True	False	linear	1	3	scale	0.0	True	False	0.001	200	False	-1	ovr	False	0.9891891891891892	0.9891635426429242
22:27:04	05/20/23	1.31 min	3	False	True	224	True	False	True	False	linear	7	3	scale	0.0	True	False	0.001	200	False	-1	ovr	False	0.9891891891891892	0.9891635426429242

Glcm Features

info				read_data					apply_glcm		SVC											metrics	
time	date	duration	id	saved	gray	new_size	normalize	transpose	distance	kernel	C	degree	gamma	coef0	shrinking	probability	tol	cache_size	verbose	max_iter	decision_function_shape	break_ties	Accuracy	F1
14:51:59	05/20/23	6.30 min	1	False	False	256	False	False	1	rbf	7	3	scale	0.0	True	False	0.001	200	False	-1	ovr	False	0.6864864864864865	0.6831443420741791

Hog Features

info				read_data					get_hog		apply_pca		SVC											metrics	
time	date	duration	id	gray	saved	new_size	normalize	transpose	block_norm	orientation	n_components	pca_obj	kernel	C	degree	gamma	coef0	shrinking	probability	tol	cache_size	verbose	max_iter	decision_function_shape	break_ties	Accuracy	F1
11:55:48	05/20/23	1.69 min	1	True	True	256	False	False	L2-Hys	9			rbf	7	3	scale	0.0	True	False	0.001	200	False	-1	ovr	False	0.827027027027027	0.8266166822867853
12:30:22	05/20/23	21.01 s	2	True	True	256	False	False	L2-Hys	9	128	PCA(n_components=128)	rbf	7	3	scale	0.0	True	False	0.001	200	False	-1	ovr	False	0.8972972972972973	0.8972492618901458
12:33:39	05/20/23	9.03 s	3	True	True	256	False	False	L2-Hys	9	128	PCA(n_components=128)	rbf	7	3	scale	0.0	True	False	0.001	200	False	-1	ovr	False	0.8378378378378378	0.8378264912033779
12:35:30	05/20/23	19.69 s	4	True	True	256	False	False	L2-Hys	9	128	PCA(n_components=128)	rbf	7	3	scale	0.0	True	False	0.001	200	False	-1	ovr	False	0.8864864864864865	0.8864732181993513
12:38:27	05/20/23	15.12 s	5	True	True	256	False	False	L1-sqrt	9	128	PCA(n_components=128)	rbf	7	3	scale	0.0	True	False	0.001	200	False	-1	ovr	False	0.8756756756756757	0.8756756756756757

LBP Features

info				read_data					get_lbp			apply_pca		SVC											metrics	
time	date	duration	id	gray	saved	new_size	normalize	transpose	radius	n_components	pca_obj		kernel	C	degree	gamma	coef0	shrinking	probability	tol	cache_size	verbose	max_iter	decision_function_shape	break_ties	Accuracy	F1
10:50:48	05/20/23	1.18 min	1	True	True	256	False	False	5				rbf	7	3	scale	0.0	True	False	0.001	200	False	-1	ovr	False	0.8324324324324325	0.832412845913328
12:41:07	05/20/23	36.44 s	2	True	True	256	False	False	5	128	PCA(n_components=128)		rbf	7	3	scale	0.0	True	False	0.001	200	False	-1	ovr	False	0.5297297297297298	0.3462897526501767

ShuffleNet Features

info				read_data				apply_deep_d			SVC											metrics	
time	date	duration	id	gray	normalize	new_size	saved	transpose	saved	eval	C	kernel	degree	gamma	coef0	shrinking	probability	tol	cache_size	verbose	max_iter	decision_function_shape	break_ties	Accuracy	F1
11:22:53	05/21/23	23.64 s	1	False	True	224	True	False	True	False	7	rbf	3	scale	0.0	True	False	0.001	200	False	-1	ovr	False	0.9891891891891892	0.9891635426429242

Logistic Regression

Hog Features

info				read_data					get_hog					LogisticRegression									metrics		apply_pca	
time	date	duration	id	gray	saved	new_size	normalize	transpose	orientation	block_norm	penalty	C	dual	tol	fit_intercept	intercept_scaling	solver	max_iter	multi_class	verbose	warm_start	Accuracy	F1	n_components	pca_obj
14:00:56	05/20/23	41.84 s	1	True	True	256	False	False	9	L2-Hys	l2	7	False	0.0	True	1	lbfgs	100	auto	0	False	0.8378378378378378	0.8378330995792427	128	PCA(n_components=128)
14:03:21	05/20/23	34.20 s	2	True	True	256	False	False	9	L2-Hys	l2	7	False	0.0	True	1	lbfgs	100	auto	0	False	0.8540540540540541	0.8540369948277373	512	PCA(n_components=512)
14:18:49	05/20/23	29.63 s	3	True	True	256	False	False	9	L2-Hys	l2	7	False	0.0	True	1	lbfgs	100	auto	0	False	0.827027027027027	0.8270219728845254	185	PCA(n_components=737)
14:21:14	05/20/23	20.62 s	4	True	True	256	False	False	9	L2-Hys	l2	7	False	0.0	True	1	lbfgs	100	auto	0	False	0.827027027027027	0.8270219728845255		

LBP Features

info				read_data					get_lbp		apply_pca		LogisticRegression												metrics	
time	date	duration	id	gray	saved	new_size	normalize	transpose	radius	n_components	pca_obj		penalty	C	dual	tol	fit_intercept	intercept_scaling	solver	max_iter	multi_class	verbose	warm_start	Accuracy	F1
14:29:58	05/20/23	1.10 min	1	True	True	256	False	False	5	512	PCA(n_components=512)		l2	7	False	0.0	True	1	lbfgs	100	auto	0	False	0.5891891891891892	0.5313333333333333
14:31:55	05/20/23	34.83 s	2	True	True	256	False	False	5				l2	7	False	0.0	True	1	lbfgs	100	auto	0	False	0.5837837837837838	0.5633716475095785
14:33:23	05/20/23	35.52 s	3	True	True	256	False	False	5				l2	10	False	0.0	True	1	lbfgs	100	auto	0	False	0.5837837837837838	0.5633716475095785
14:34:33	05/20/23	41.61 s	4	True	True	256	False	False	5				l2	100	False	0.0	True	1	lbfgs	100	auto	0	False	0.5837837837837838	0.5633716475095785
14:35:37	05/20/23	27.15 s	5	True	True	256	False	False	4				l2	100	False	0.0	True	1	lbfgs	100	auto	0	False	0.7027027027027027	0.6935333273094184
14:36:29	05/20/23	21.93 s	6	True	True	256	False	False	4				l2	100	False	0.0	True	1	lbfgs	100	auto	0	False	0.5945945945945946	0.5864258249128143
14:37:17	05/20/23	21.35 s	7	True	True	256	False	False	3				l2	100	False	0.0	True	1	lbfgs	100	auto	0	False	0.6162162162162163	0.6140057010197184
14:38:15	05/20/23	1.73 min	8	True	True	256	False	False	4	512	PCA(n_components=512)		l2	100	False	0.0	True	1	lbfgs	100	auto	0	False	0.7567567567567568	0.7560439560439560

QDA

HOG Features

info				read_data				apply_rand_d		QuadraticDiscriminantAnalysis			metrics	
time	date	duration	id	saved	gray	new_size	normalize	n_bins	saved	eval	reg_param	store_covariance	tol	Accuracy	F1
01:59:02	04/22/23	3.80 s	1					10	False	False	0.0	False	0.0	0.8162162162162162	0.8159527153558053
01:59:32	04/22/23	1.20 min	2					10	False	False	0.0	False	0.0	0.7243243243243244	0.7077952243798198
12:37:19	04/22/23	1.11 min	3					10	False	False	0.0	False	0.0	0.8162162162162162	0.8159527153558053
12:42:18	04/22/23	4.08 s	5	True	False	256	False	10	False	False	0.0	False	0.0	0.8162162162162162	0.8159527153558053

LBP Features

info				read_data					get_lbp	apply_pca		QuadraticDiscriminantAnalysis			metrics	
time	date	duration	id	gray	saved	new_size	normalize	transpose	radius	n_components	pca_obj	reg_param	store_covariance	tol	Accuracy	F1
00:01:07	05/20/23	4.61 min	1	True	False	256	False	False	3			0.0	False	0.0	0.4594594594594595	0.4558823529411765
00:11:11	05/20/23	1.05 min	2	True	False	256	False	False	4			0.0	False	0.0	0.5135135135135135	0.5131578947368421
10:39:34	05/20/23	1.21 min	3	True	True	256	False	False	4			0.0	False	0.0	0.5135135135135135	0.5131578947368421
10:42:43	05/20/23	56.13 s	4	True	True	256	False	False	5			0.0	False	0.0	0.5351351351351351	0.5351215521271623
12:48:10	05/20/23	37.85 s	5	True	True	256	False	False	5	128	PCA(n_components=128)	0.0	False	0.0	0.5297297297297298	0.3462897526501767
12:53:04	05/20/23	39.58 s	6	True	True	256	False	False	4	512	PCA(n_components=512)	0.0	False	0.0	0.6216216216216216	0.6191176470588236

Per Pixel Segmentation

Since there were no supplied masks with the segmentation problem, it's an unsupervised task. We've used a clustering approach to achieve an unsupervised segmentation.

The clustering methods used:

- K Means
- Isodata

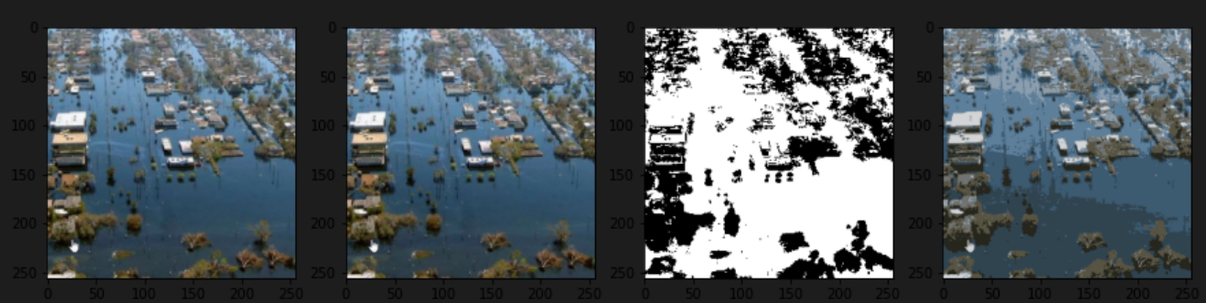
K Means

The rgb-image was clustered by color using 5 clusters.

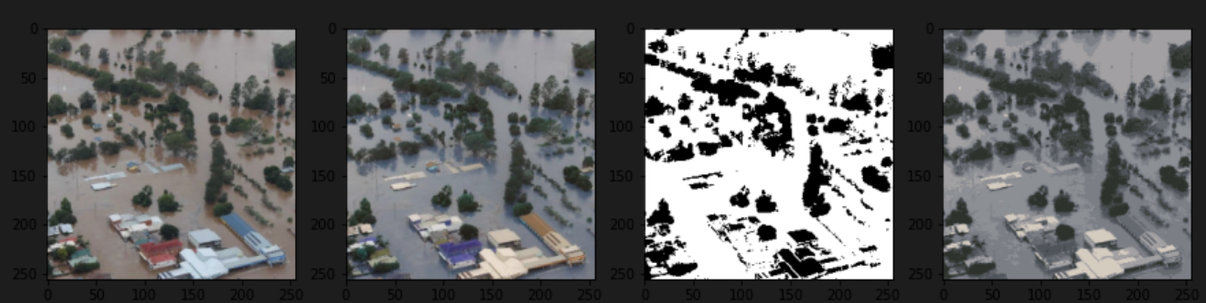
We've noticed that there's some light reflectance in the flooded water. To achieve robustness against different illumination effects, the center of the clusters is transformed from rgb to hsv color space, then the hue of each cluster center is compared with the hue of the water, if it lies within it, that cluster is segmented as water.

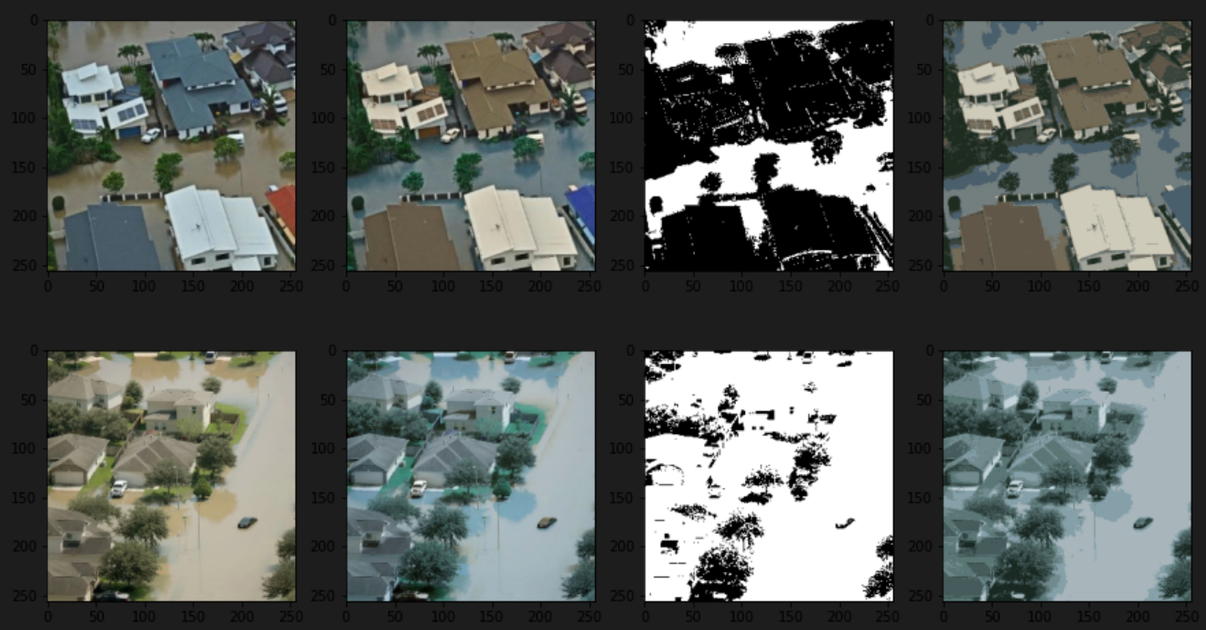
We've noticed that the water in some flooded images is more reddish than blue. To achieve robustness against such cases, the average pixel colors were calculated, when it's more reddish the blue and red channels are swapped.

Segmentation Results

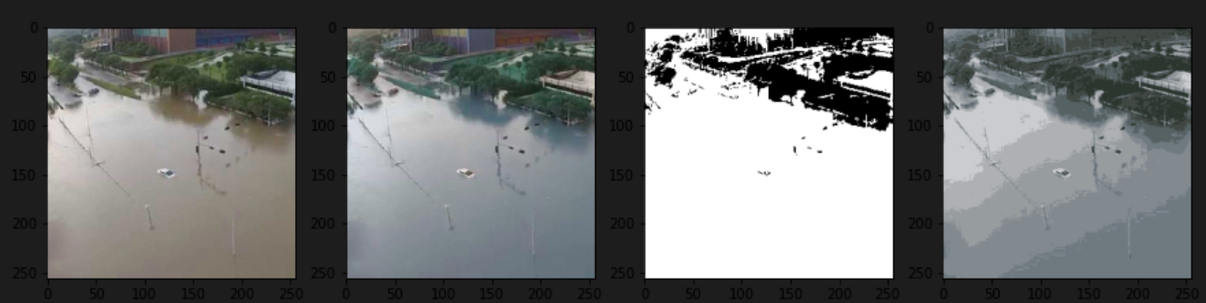


Reddish water Segmentation Results

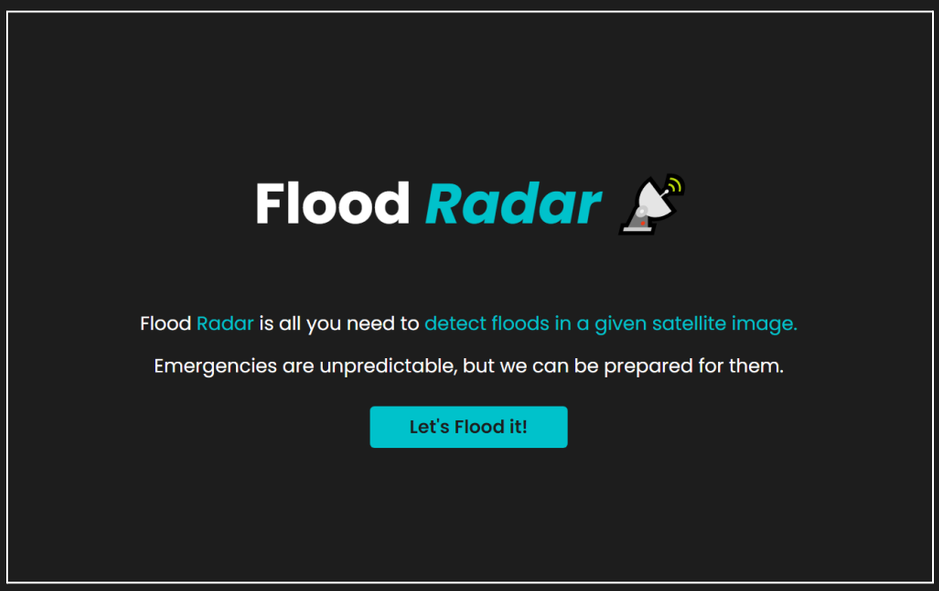


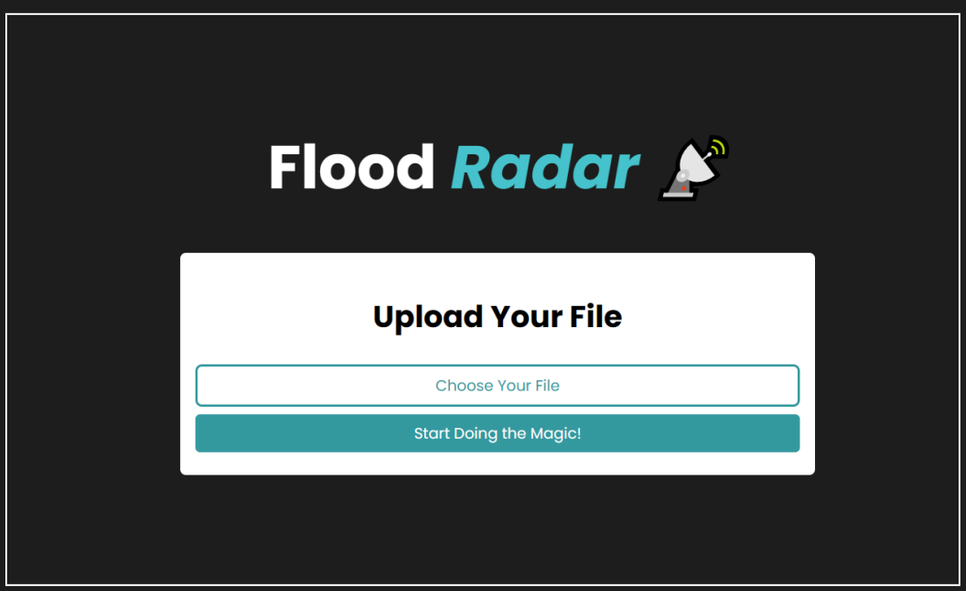


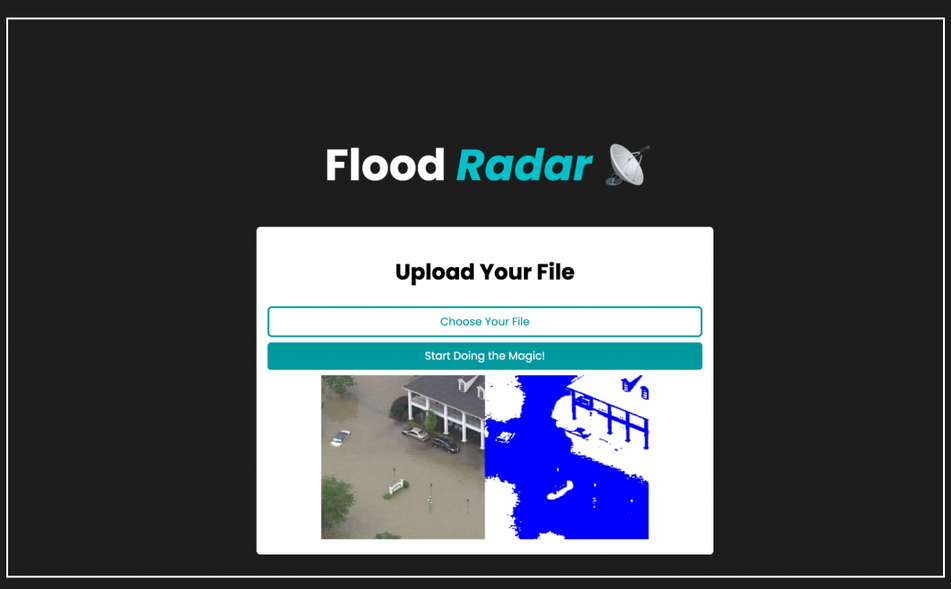
Illumination-robust Segmentation results



Application







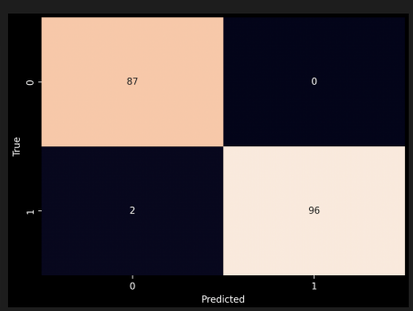
Results & Evaluation

The best results were achieved by the extracting embeddings via shufflenet then classified them using SVM, with results of

Accuracy	error of omission for non flooded class	error of commission for non flooded class	error of omission for flooded class	error of commission for flooded class	F1
98.918%	0	0.022	0.02	0	98.916%

Classification Report & Confusion Matrix for shufflenet with SVM:

	precision	recall	f1-score	support
0	0.978	1.000	0.989	87
1	1.000	0.980	0.990	98
accuracy			0.989	185
macro avg	0.989	0.990	0.989	185
weighted avg	0.989	0.989	0.989	185



Results for all experiments:

Experiment	F1-score
HOG-LR	0.8540369948277373
LBP-LR	0.756043956043956
GLCM-SVM	0.6831443420741791
HOG-SVM	0.8972492618901458
LBP-SVM	0.832412845913328
Shufflenet-SVM	0.9891635426429242
Resnet-SVM	0.9787926095635422
Hist-QDA	0.8159527153558053
LBP-QDA	0.6191176470588236