

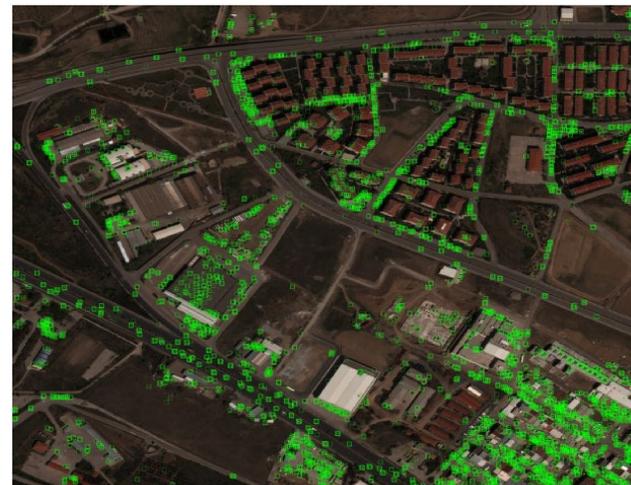
CIFT

Circularly Invariant Feature Trees

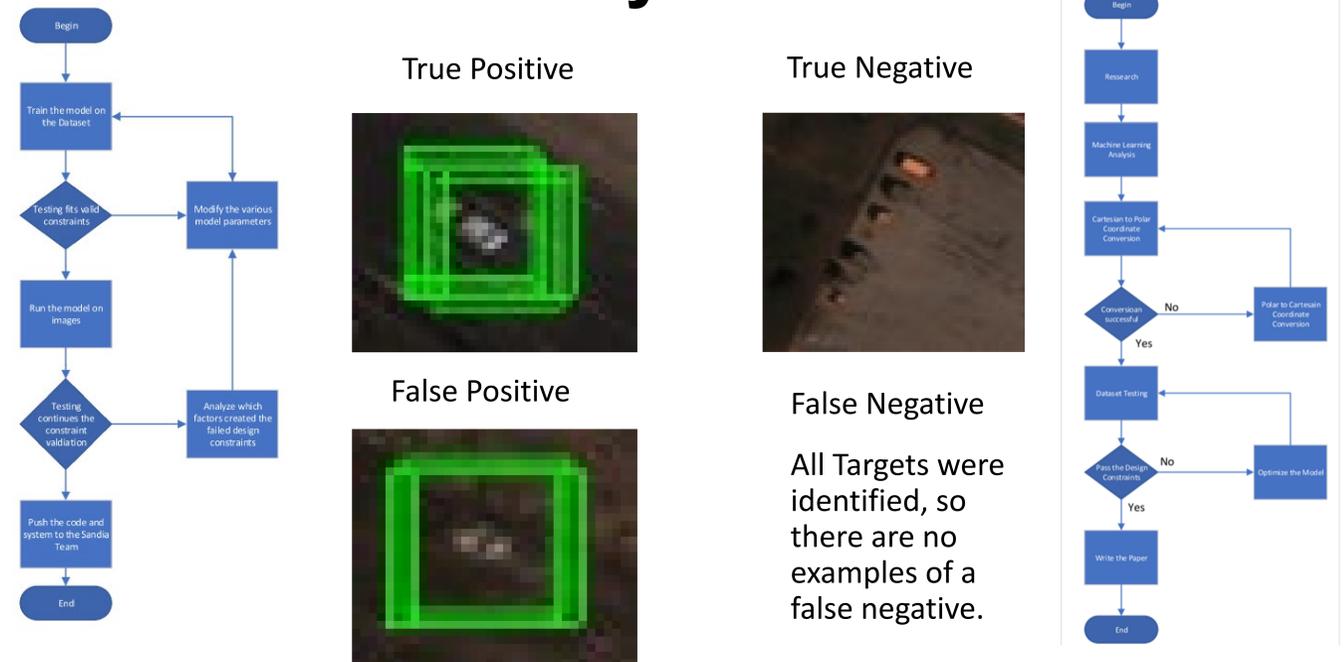
Project

The Bode Description Project implemented a random forest Machine Learning model from decision trees to identify and classify targets within an image. Correct development of this AI model will utilize an FFT to obtain a rotationally invariant feature within the model and allow for efficient usage of time and hardware while giving an accurate depiction within the model.

A common problem among image analysis is how rotational variance affects the model. A car, airplane, etc. may be oriented any which way. Running every possible orientation costs RAM, computation, and time. The problem is to develop a model that has rotationally invariant qualities, such that the model may identify the same target at any other orientation.



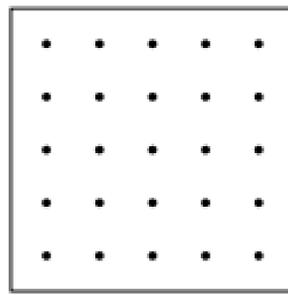
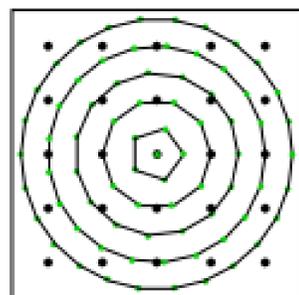
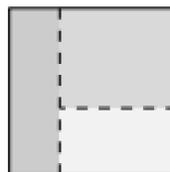
System



Methods

Polar to Cartesian Coordinate Conversion

A tree contains several layers to output a value dependent on the input values. The model employs several trees to form a forest. The output from these trees is put into a vector of scalar values to weigh the outputs and determine a positive or a negative detection. An FFT is then applied to give the model its rotationally invariant feature.



$$h(x, y) = \begin{cases} b_1 & x_2 \leq \tau_2 \\ a_1 & x_2 > \tau_2 \\ c_1 & x_1 > \tau_1 \end{cases} \quad \begin{matrix} x_1 \leq \tau_1 \\ x_1 > \tau_1 \end{matrix}$$

Conclusion

The model takes 2.15 hours to scan an image—employing a parallel architecture over 36 CPUs.

The chosen parameters were then determined to be 1.4 radii increments, 1.65 arc length increments, and a sub-image size of 25x25. This performs well while maintaining a precision and recall optimization.

Radius	Arc Length	Points	Precision	Recall	F1 score	ConfusionMatrix			
0.5	0.5	1873	87.13784	89.253597	88.183029	1985	293	239	3633
1	0.5	825	87.472527	89.478417	88.464103	1990	285	234	3641
0.5	1	931	87.43897	88.579137	88.005361	1970	283	254	3643
1	1	410	87.158836	87.589928	87.373851	1948	287	276	3639
1.5	1	261	87.088156	87.94964	87.516778	1956	290	268	3636
1	1.5	272	87.730871	89.703237	88.706091	1995	279	229	3647
1.5	1.5	173	86.883059	87.859712	87.368656	1954	295	270	3631
2	2	93	86.602027	88.354316	87.469397	1965	304	259	3622

Table 3-2. Multi-class Classifier: Performance as a function of tree depth and number of trees

Tree Depth	# of trees	Subimage Size	Radius	Arc Length	Precision	Recall	F1 Score	Score
4	1000	25	1.4	1.65	98.22	89.6	96.82	85.36
5	1000	25	1.4	1.65	99.18	80.87	97.69	84.05
6	1000	25	1.4	1.65	98	89	95.7	85.698
5	800	25	1.4	1.65	99.65	111.111	88.544	33.333
5	1200	25	1.4	1.65	99.34	20	93.25	66.666