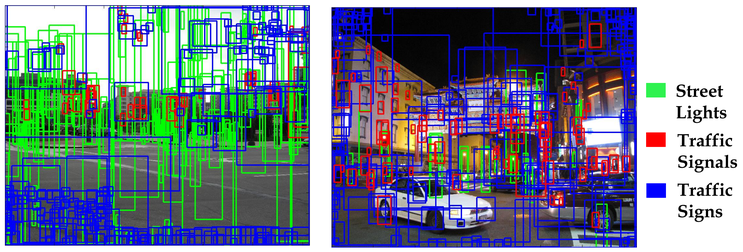
GIS-Assisted Object Detection of Outdoor Scenes

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1. Problem

- **Object Detection:**
  - Many false positives and few true positives for challenging urban images.
  - Making object detection more accurate.
- **Applications:**
  - Autonomous image tagging, geospatial estimation, etc.



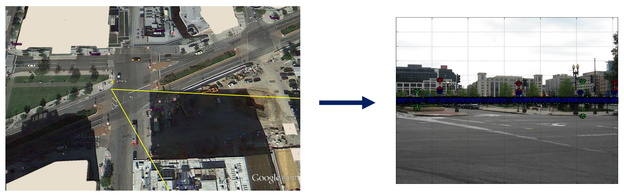
1.1 Our Approach

- Use GIS data to create an estimation for the ground truth.
- True detections should compose an arrangement similar to that of the estimated ground truth.
- Most false detections should completely disagree with the estimated ground truth.

2. Our Framework

2.1. Perspective Projection of GIS Data Onto the Image Plane

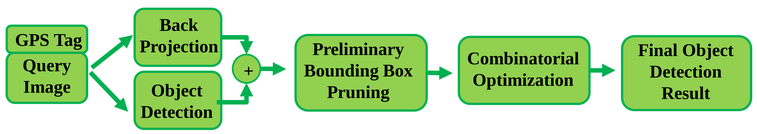
- Using sensor model for back projection.



2.2. Occlusion Handling

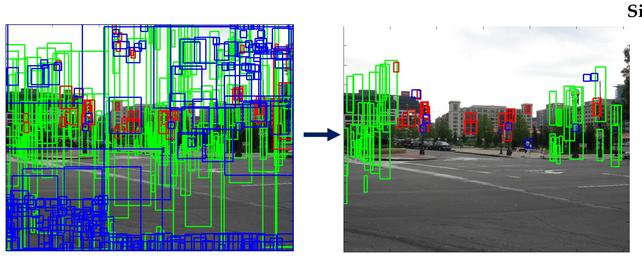
- Occlusion segments: Buildings, Foliage, other objects.





2.3. Coarse Pruning of Object Detections

- Preliminary sifting of bounding boxes [1] that disagree with our back projection.



2.4. Cost Function

- Generate all possible combinations of pruned bounding boxes.
  - Assign cost to each.

$$cost = \sqrt{2 * std_x^2 + std_{y1}^2 + std_{y2}^2}$$
$$std_x = std(GIS_{px} - combination_{ix})$$
$$std_{y1} = std(GIS_{py1} - combination_{iy1})$$
$$std_{y2} = std(GIS_{py2} - combination_{iy2})$$

2.5. Combinatorial Fusion

- Resultant minima among combinations is chosen as best arrangement.

$$BestArrangement = \underset{combination_i}{argmin}\ cost(GIS_{GT}, combination_i)$$

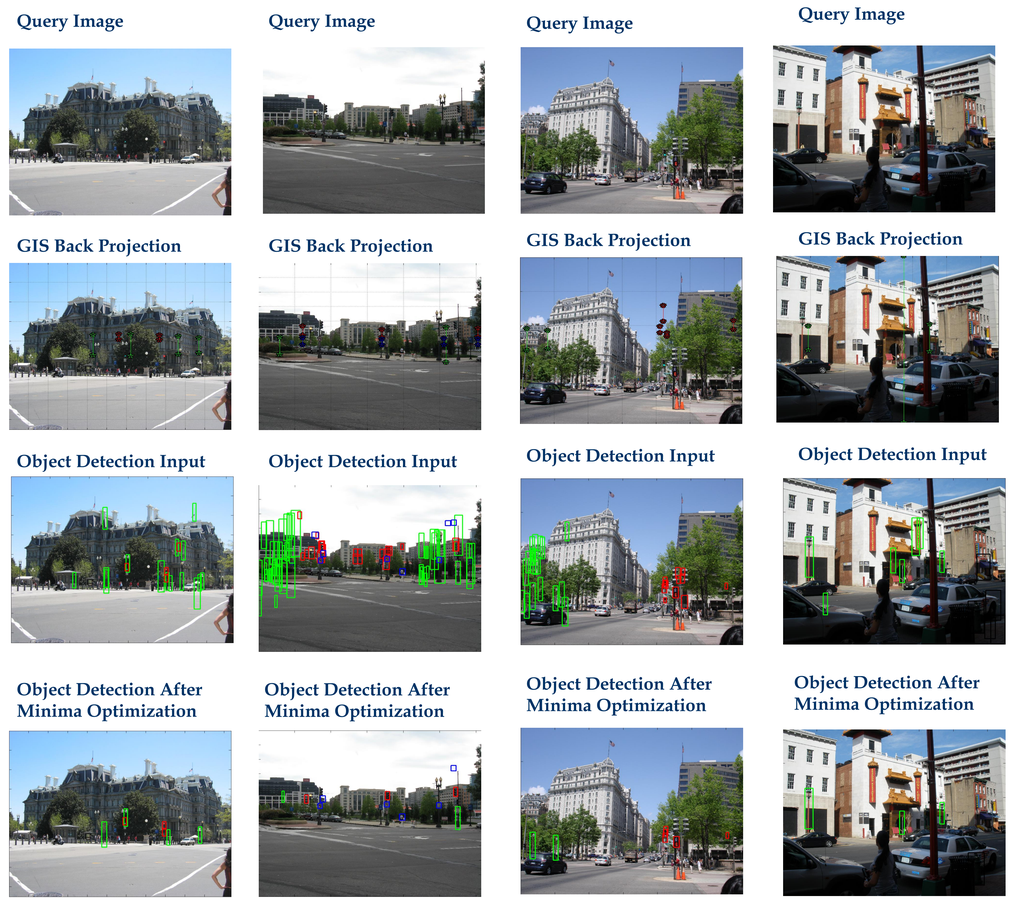


3. Combinatorial Optimization

- Tractability:
  - Possible multi-class combinations can be extremely vast
- Find the best bounding boxes by fusing two classes at a time.
- Our algorithm is then ran for multiple classes using only the reduced set of bounding boxes.

4. Results

- Panoramio Images: 4000 GPS-tagged images from Washington D.C. . 20 query images hand picked.



5. Conclusion

- Fusion of GIS with content-based object detectors significantly improves the results.
- GIS has inaccuracies which has to be taken into account.
- A suitable optimization method is essential.
- Camera parameters have inaccuracies or unknowns as well:

Next Steps

- Develop a more complex cost function to further improve our results.
- Early fusion of GIS with object detectors.
- Large scale standard evaluation..

References

[1] P. Felzenszwalb, R. Girshick, D. McAllester, D. Ramanan
"Object Detection with Discriminatively Trained Part Based Models"
IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 32, No. 9, Sep. 2010