TROPICAL CYCLONE INTENSITY ESTIMATION FROM SATELLITE IMAGES

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Abstract

- Developing new automated techniques to estimate the TC intensity and to overcome the existing errors in estimation is still a challenge
- The Dvorak technique (DT) is the state-of-the-art method that has been used over three decades for estimating the intensity of a tropical cyclone (Velden et al. 2006)
- We have developed and tested an automated method to estimate TC intensity based on the existing historical data

Goal

- Tropical cyclones (TCs) are a significant threat to life and property
- An accurate measure of the current intensity is a must to accurately forecast TC intensity
- Hypothesize that discovering unknown regularities and abnormalities that may exist in the large group of past observations could help human experts interpret TC intensity changes from various points of view
- Provide a data mining tool that increases the ability of human experts to analyze huge amount of historical data for TC intensity estimation

Introduction

- Estimating tropical cyclone intensity (INT) from:

$$INT = f(g(x,y),t)$$

- In this mapping, the spatial interpretation of satellite imagery, $g(x,y)$ is constrained in time (t) by some function, f
- This is similar to Dvorak intensity estimation, where T-numbers are constrained in time to estimate current intensity (CI)
- The focus of this study is on the spatial interpretation of satellite imagery, $g(x,y)$

Database: North Atlantic HURSAT-B1

Product	Hursat-B1
Temporal span	1978 - 2009
Spatial span	Storm-centric: 10.5° from center for all global TCs
Temporal resolution	3 hourly
Gridding resolution	8km
Data source	ISCCP B1
Channels available	IRWIN (11μm) IRWVP (6.7μm) (0.65μm)
Calibration	Clim. – IRWIN, ISCCP - IRWVP,
Yearly size (GB)	< 6.5
Format	NetCDF
Current version	5.0
Imagery	Movies

- HURSAT data (Knapp and Kossin 2007)

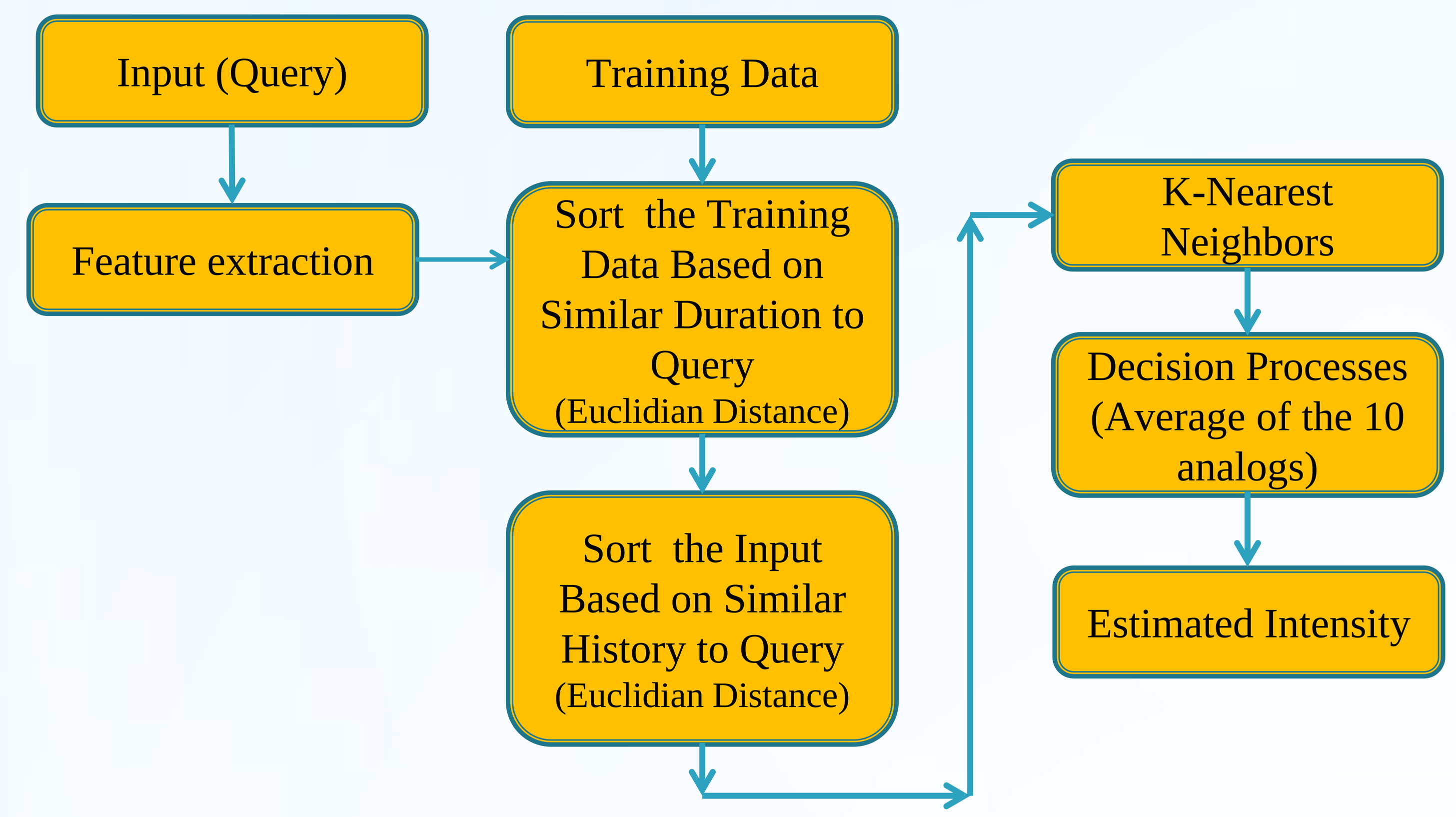
- The data restricted to only include fixes that cover water and are south of 45˚N. This subset comprises 2,016 measurements in 165 storms from 1988 – 2006
- We considered the best track intensity estimates to be those with aircraft reconnaissance within 12 hours

Method: Intensity Estimate from Image Analysis

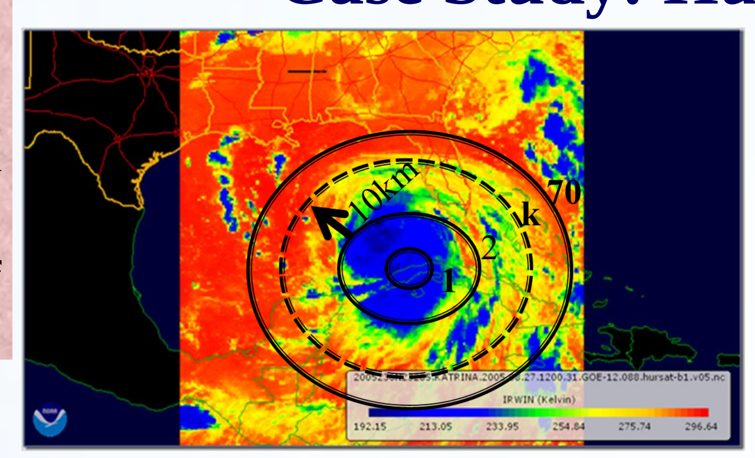
- The intensity estimation algorithm uses satellite images for intensity analysis
- Proposed technique uses the *age* (*duration*) of the cyclone, *current*, 6, 12 and 24 hour prior images as predictors of the estimated intensity.
- *Current* and the preceding 6, 12 and 24 hour images expressed by brightness temperature (BT) (mean and standard deviation) of the 14 rings around the center of the storm

$$INT = f\,(g(x,y),\ g(x,y)_{t-6},\ g(x,y)_{t-12},\ g(x,y)_{t-24},\ AGE)$$

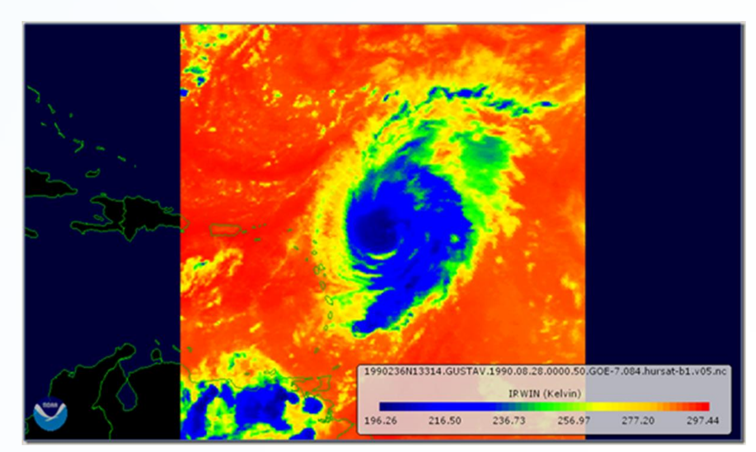
- Several tests are implemented to statistically validate the proposed algorithm using k-Fold Cross-Validation



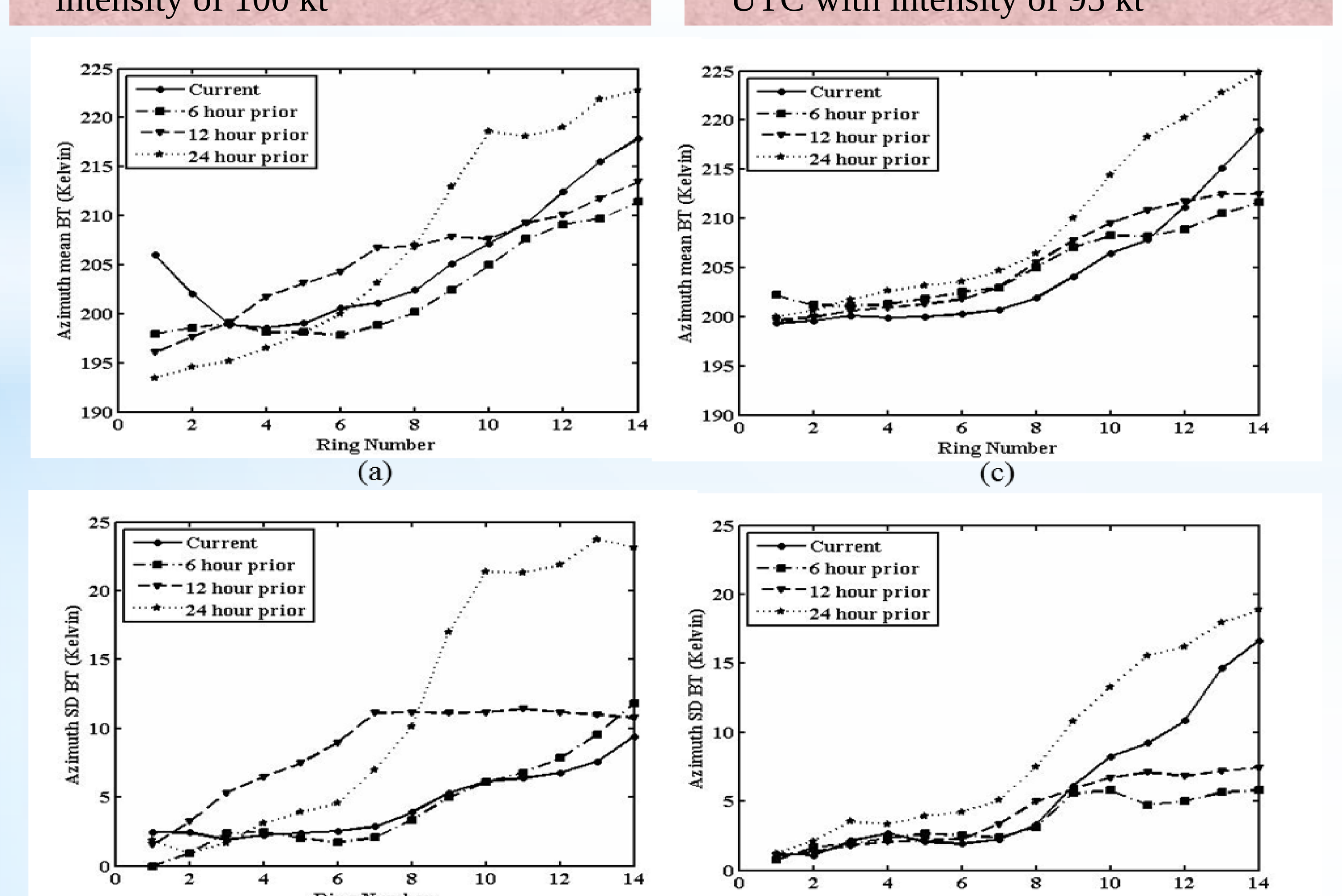
Case Study: Hurricane Katrina



- Query: Hurricane Katrina for a given date (2005.08.27) at 12:00 UTC with intensity of 100 kt



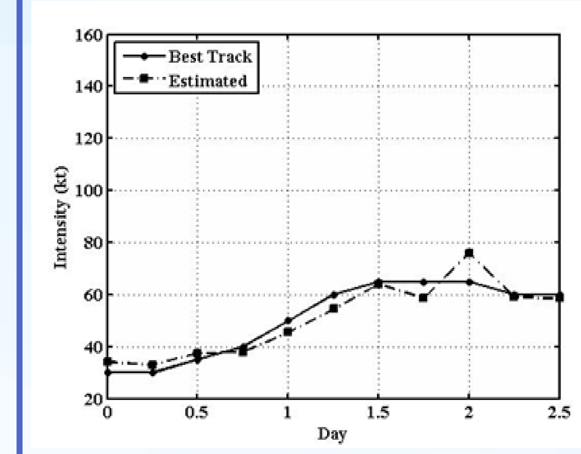
- Nearest Neighbor: Hurricane Gustav for a given date (1990.08.28) at 00:00 UTC with intensity of 95 kt



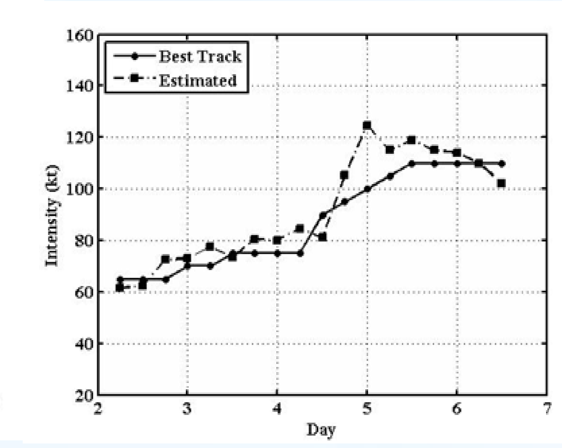
- Azimuthal BT mean (a) and SD (b) of the query (Katrina 2005) and mean (c) SD (d) of NN (Gustav 1990) .

Results for Selected storms

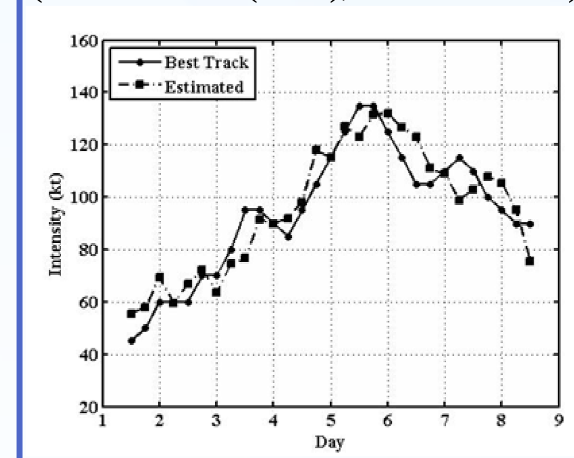
- Errors are on par with other automated algorithms



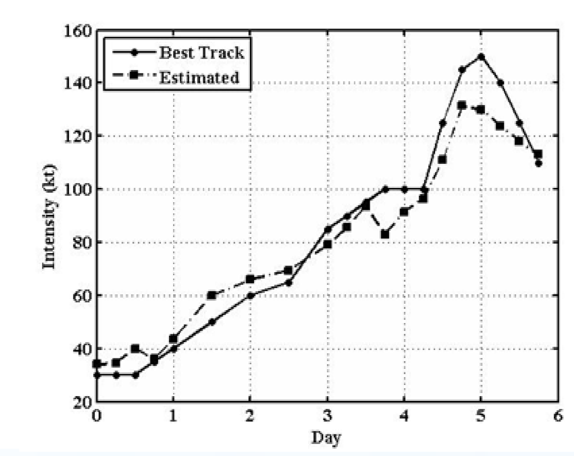
(storm Allison (1995), MAE= 3.86 kt)



(storm Erica (1997), MAE= 6.97 kt)



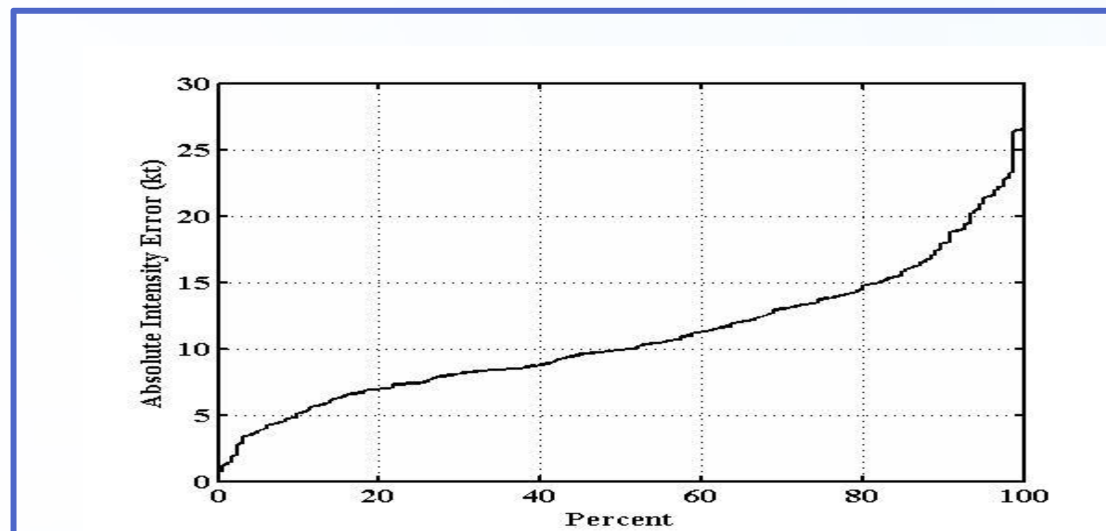
(storm Floyd (1999), MAE=7.46 kt)



(storm Katrina (2005), MAE= 7.91 kt)

- Results of our technique compared with best track data

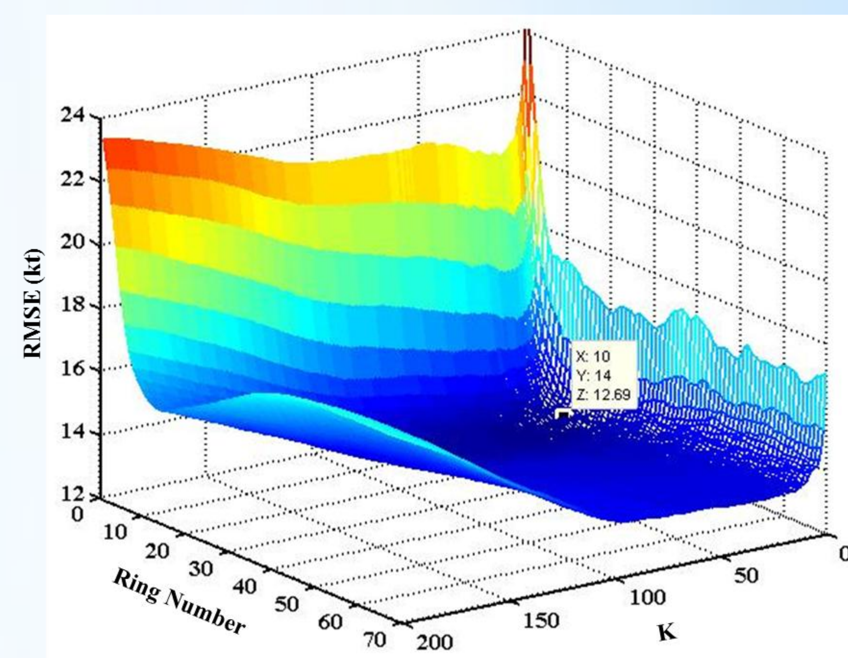
Results of Image Analysis



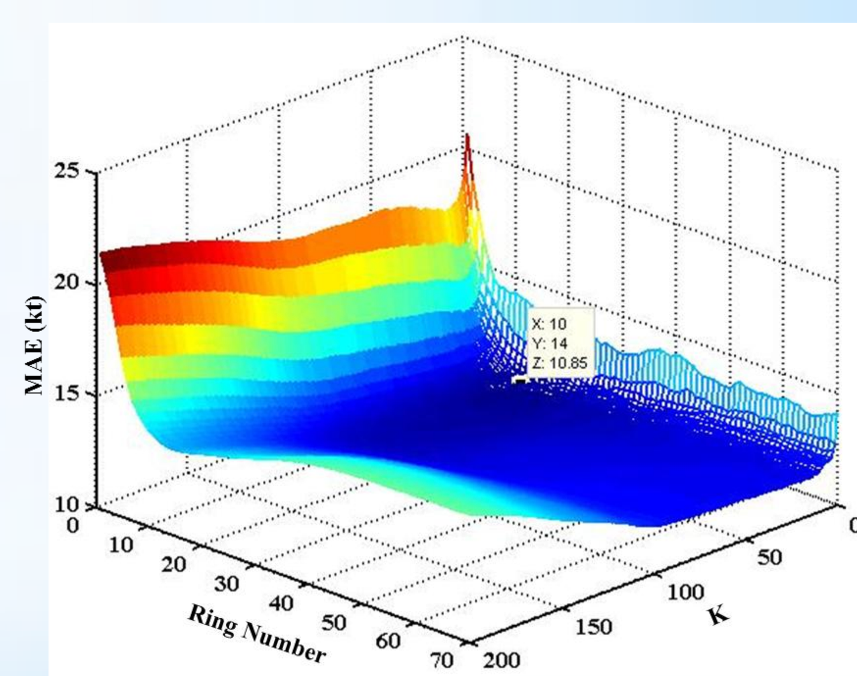
- 90%, 75% and 50% of the mean absolute errors of proposed technique are less than 18 kt, 14 kt and 10 kt respectively

Sensitivity analysis of the selected parameters

- The number of similar images (K) used to estimate the intensity and the numbers of the rings around the center of storm were determined based on their effect on the average changes in the values of MAE and RMSE
- This is done by changing the values of K and the ring number from 1 to 200 and 1 to 70 respectively and choosing the parameters with the minimum error values in n-fold cross validation
- Values for parameters were selected as K equal to 10 and the number of the rings as equal to 14



Variations of the average RMSE versus K and ring number



Variations of the average MAE versus K and ring number

Conclusion and Future work

- Image analysis mean absolute error is 10.85 kt (50% of points are within 10 kt)
- Its accuracy is on par with other objective techniques, with the added advantages of simplicity, objectivity and consistency
- Future work to improve the technique could include adding temporal constraints on the estimated intensity and increasing the number of training samples at higher intensities

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