Visualizing the Uncertainty in Hurricane Path Prediction

Donald House
NHC Visit
Miami, FL
March 13, 2014
Outline

• Uncertainty cone visualization
• Alternative ensemble visualization
  – review of the algorithm
  – experimental evaluation
  – ideas to move forward
  – demonstration
Uncertainty Cone

- Binary display
- Missing 1/3 of outcomes
- Predicted path overemphasized
- Cone open to misinterpretation
- Time represented
- Simple graphic
Proposed Ensemble Display

- Distribution explicit
- No hard boundary, has outlier hinting
- No predicted path
- Tracks are intuitive
- Time not represented
- Distributed graphic
Ensemble Display is dynamic
Ensemble Display is dynamic
Two Models Used for Path Generation

- Predicted: based on the current NHC advisory
  - Set of pdf’s distributed over time

- Historical: based on historical hurricane behavior
  - Set of pdf’s distributed spatially
For each 3 hour segment on uncertainty cone edge and predicted path
get initial and final bearing
calculate bearing change
2-sided normal distribution
predicted path is mean cone sides are 2 sigma
Similar idea for speed
Historical Model

Gulf tracks since 1945
Historical Model

basic spatial cell
Historical Model

Extrapolation of paths

Kernel density estimator
Algorithm

Input: current NHC advisory
Build pdfs for predicted and historical models
Empty the list of tracks
loop forever
  Generate New Track
  Store in track list with time stamp
  Lower opacity of tracks with age
  Delete completely transparent tracks
  Display all tracks
Algorithm

**Generate New Track**

*Input:* prebuilt pdfs, advisory, path list

- start with advisory speed and bearing
- for each 3 hour time step do
  - *Determine Speed and Bearing Change*
  - integrate over 3 hours
  - update position, speed, and bearing
Algorithm

Determine Speed and Bearing Change
Input: pdfs, time, speed, bearing, advisory, path list

Choose Predicted or Historical Model

If predicted model
    select pdf by time
else
    select pdf by position, speed & bearing
sample pdf for bearing and speed change
Algorithm

Choose Predicted or Historical Model

Input: advisory, path list

If > 68% of paths lie in uncertainty cone
  95% historical, 5% predicted
else
  1% historical, 99% predicted
Experimental Evaluation
Experimental Evaluation
Experimental Evaluation

Average mean direction by case
Experimental Evaluation

profiles with low and high significant difference
Least and Most Similar Cases

Case 3
Least Similar

Case 6
Most Similar
User Survey

• 26 participants
• All but one preferred ensemble display
  – mean 1.56 out of 5, s.d. 0.53
• Consistent critique of ensemble display
  – visually interesting and provided better insight
  – but, more cognitively demanding
Looking ahead: adding Interaction
Looking ahead: adding Interaction
Demonstration