Display Of Trajectory Predictions Using Uncertainty Visualization Methods

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INTRODUCTION

RESEARCH QUESTION
- Motivations
- Connections with automation

Case study
- LIGHT GENERAL AVIATION CONTEXT
- QUICK COMPARISON BETWEEN COMMERCIAL AND LIGHT GENERAL AVIATION
- PREDICTING LIGHT GA FLIGHTS
- CHALLENGES: 2 kinds of prediction

1ST OBJECTIVE: PRELIMINAR PROTOTYPE
- UNCERTAINTY EMULATION
- FIRST VISUALIZATION USING VISUAL VARIABLES
- ALTERNATIVE FOR PLANNING

QUICK REVIEW OF THE VISUALIZATION METHODS

POOL OF VISUALIZATIONS – POOL OF SITUATIONS
- INTERVIEW RESULTS (WITH EXAMPLES OF SITUATIONS)

CONCLUSIONS AND FUTURE/CURRENT STEPS
• It is very difficult to get rid of uncertainty
• Automation + human in the loop may lead to decisions with uncertainty: ex predictions
• Ignoring the uncertainty can lead to wrong/dangerous decisions
• Must be represented in the proper way
  • Semiology: you need to associate the used representation to the uncertainty
  • Cluttering
  • Useful: it must be useful for the task and lead you to a better/safer decision (need to be tested in borderline situations)
Questions from the HALA position paper

- “Does uncertainty requires human centered decision making?”
- “How can uncertainty be managed in automated systems?”
research question

- What are the ways that better convey the uncertainty to the users?

- Does the presentation of uncertainty influence the decisions of users? If yes, in which way?
ProGA main objective: study the feasibility of a system that can continually and automatically predict the future GA aircraft’s flight corridor or its volume of operation.

Essentially make predictions with a lot of uncertainty.

Definition of automation: replaces (partially or totally) manual or cognitive operations.

Pilots do try to predict other flights. ProGA is replacing the cognitive process of the prediction.
CASE STUDY: LIGHT GENERAL AVIATION

COMMERCIAL AVIATION
- CONTROLLED AIRSPACES
- IFR
- NETWORK
- NOT EASY TO PREDICT

LIGHT GENERAL AVIATION
- G
- VFR
- FREE
- @ @
Case study: ProGA concept

- Business Intelligence
  - Flight path classification
  - Flight path acquisition
  - Typically flown paths
  - OFFLINE

- Short-term prediction
- Matching
- Long-term prediction
  - ONLINE
case study/1st prototype

- Objective: build a first prototype
- Uncertainty emulator
  - Abstracting from the algorithms
  - Quantify the amount of data to visualize
  - Testing feasibility: heavy computation on small devices
  - Obtaining realistic data
- Feasibility check
- 1st Evaluation
/case study/uncertainty emulation

• Prediction structure

  t1  t2  t3  ...

  Geographic matrix in which each cell contains the probability for the aircraft to be there
/case study/uncertainty emulation

Start from existing trajectory
• Pretend to be on to
• Use future points as centers for generating random positions (random distance, random direction from center)
• Assign them a probability
case study/1st prototype
case study/1st prototype
PM10 concentration data (left) and uncertainty of the PM10 data (right) over Europe are represented on two side by side maps.
uncertainty visualization methods/contours
Evaluating Sketchiness as a Visual Variable for the Depiction of Qualitative Uncertainty, Boukhelifa 2012
Usability of Spatio-Temporal Uncertainty Visualization Methods, Hansi Senaratne, Lydia Gerharz, Edzer Pebesma, Angela Schwering, 2012
Uncertainty visualization methods

- color schemes
- whitening
- symbols
- opacity
- animated isolines
- error bars and intervals with web client
- animation
- statistical dimension in a GIS
- blinking pixels
- blinking regions
- hierarchical spatial data structures
- Glyphs
- Combination of methods
uncertainty visualization methods/gaps

- Often designed for non real-time decisions
- Uncertainty in ATM is usually something you want to get rid off
  - When uncertainty is used in ATM, ad hoc solutions are designed
/uncertainty visualization methods/atm

probabilistic conflict detection for a crossing conflict

Evaluation of Advanced Conflict Modelling in the Highly Interactive Problem Solver, Bas van Doorn, Bert Bakker, Colin Meckiff - 2001
Showing uncertainty on the prediction of the arrival times

Supporting Arrival Management Decisions by Visualising Uncertainty, Maarten Tielrooij, Clark Borst, Max Mulder, Dennis Nieuwenhuisen 2013
User interviews will identify the pool of specific situations

Methods from literature + New concepts

Level 0 Prototype

Level 1 Prototype
/user interviews

• Preliminary results on desired supports
  • Planning
  • Historical data as experience representation during flight
    • Ex: typical traffic flows for the different kind of flights
  • In-flight re-planning based on the predictions
    • Ex: pilots on training flights can decide to perform different training exercise depending on the traffic prediction
conclusions + future steps

• Define the thresholds under which uncertain data is not usable anymore
• Separate emulation and visualization
• Refine user requirements
• Design and develop a precise depiction concept for the identified situation
• Ways to interact with the uncertainty if needed
• Assess whether the uncertainty has an impact on the decision making process and on its outcome
/thank you

- questions
- feedbacks