Data processing for the aircraft weather avoidance model

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Overview

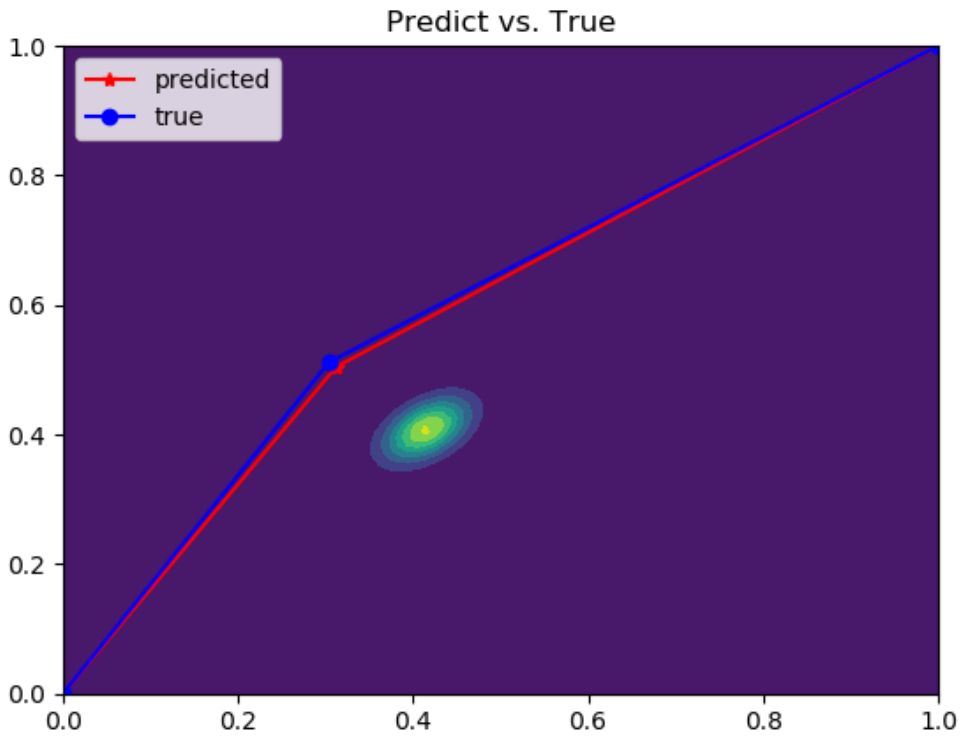
Background

Convective Weather plays as a significant impediment to Air Traffic Management systems and sometimes leads to the unnecessary delays of an aircraft. It is report that 70% of delays in the NAS are caused by weather, and of those delays, 60% are specifically accounted for by convective weather[Clifford, S.F., et al., 2003]. Algorithms to solve this problem is a key part on design of next generation of ATM systems.

Erzberger[Erzberger, H., et al., 2010] proposed a weather cell avoidance algorithm which is first fitting a polygon to the boundary of the weather cell, then find the path around the polygon.

Previous Work

We are trying to learn the rule of weather avoidance used in the society from the historical record in a few database. We made up some data depending on the rules stated previously then learn the model from it.



Network Configuration	
Layer number	Layer Type
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2	3x3-Conv-32
3	2x2-maxpool
4	3x3-conv-64
5	3x3-conv-64
6	2x2-maxpool
7	3x3-conv-128
8	3x3-conv-128
9	2x2-maxpool
10	512-fc
11	64-fc
12	2-sigmoid

Database

The data is download from the Sherlock ATM Data Warehouse which is a integrated system which can store and process raw data received from different facilities. It includes a few data sources for flight data, airport data and weather data[MoreInfo].

We only need two of them,

- Processed FAA Flight Data
- CIWS[D.Klingle-Wilson and J.Evans, 2005](Corridor Integrated Weather Systems) data

FAA

The FAA source will need you to specify a date, time range and area to download the data. It will put everything in a single csv file. The file will contain time, callsign, real trajectory data and flight plans.

15214	3	1491456005.307	13358	1620	904	0/NCT	AIG200	VRD029	1	37.5473	-122.15025	32	10	0.5	#	
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15218	4	1491429927	13569		611	0/ZDC	FH	AAL1362	1	B738	KIAD	KLAX	N		#	KIAD.BUNZZ3.RAMAY.Q72.HACKS.J149.EMPTY.J80.VHP..KK60K
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15225	4	1491435171	13569	3642		0/IAD	0xE02	AAL1362	1	B738	?	?	N			?
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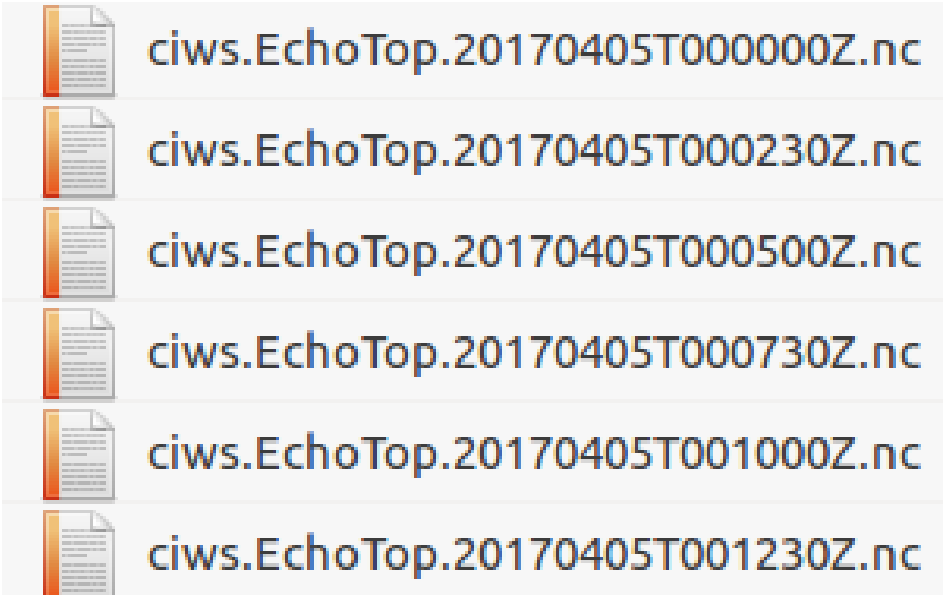
CIWS

There are two key weather features available from CIWS,

- EchoTop
- VIL(vertically integated liquid)

They are in a similar format which contains the values received from facilities within the United States Air Space.



Data Parsers Created

FAA Parser

CIWS Parser

Flight CallSign Parser

FAA Parser

Algorithm 1 FAA Parser Algorithm

```
Initial New Flight Plan, Change Time, Trajectory
for chunk in datafile do
    Clean ? and NaN
    if CallSign Match then
        return row indices
        if New Flight Plan then
            Append New Flight Plan and Change Time
        else if Trajectory then
            Append Trajectory
        end if
    end if
end for
return  New Flight Plan, Change Time, Trajectory
Save CSV
```

CIWS Parser

Algorithm 2 CIWS Parser Algorithm

1: Switch Unix Time
2: Search Nearest Value in the Directory
3: Load Corresponding Data File
4: **if** Given Start and End Index of Latitude and Longitude **then**
5: Crop, Resize, Normalize
6: **end if**
7: Plot
8: Save Figure

Flight CallSign Parser

Algorithm 3 Flight CallSign Parser Algorithm

1: Load CSV
2: Initial CallSign
3: **for** *chunk* in *csvfile* **do**
4: Take out the CallSign Column
5: Remove Repeated Rows and Clean Irrelevant Entries
6: Append CallSign
7: **end for**
8: Write

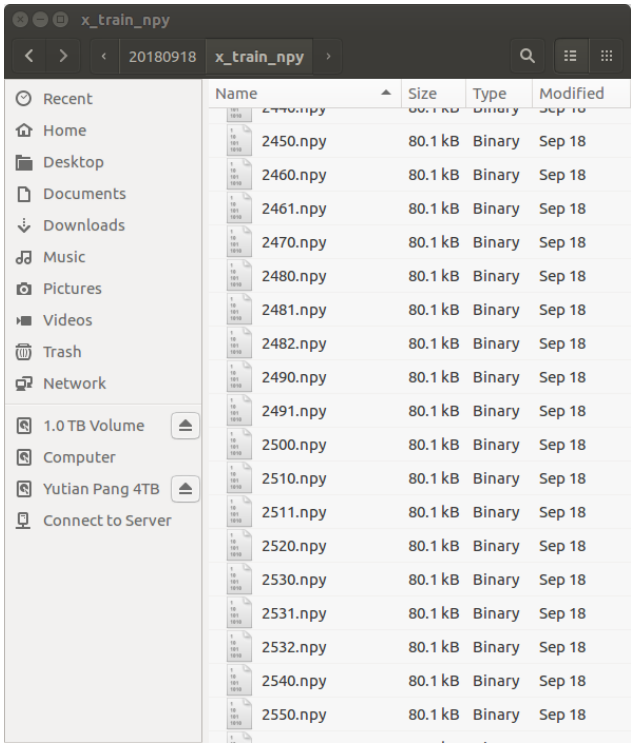
Put Them Together

Algorithm 4 Fetch Data

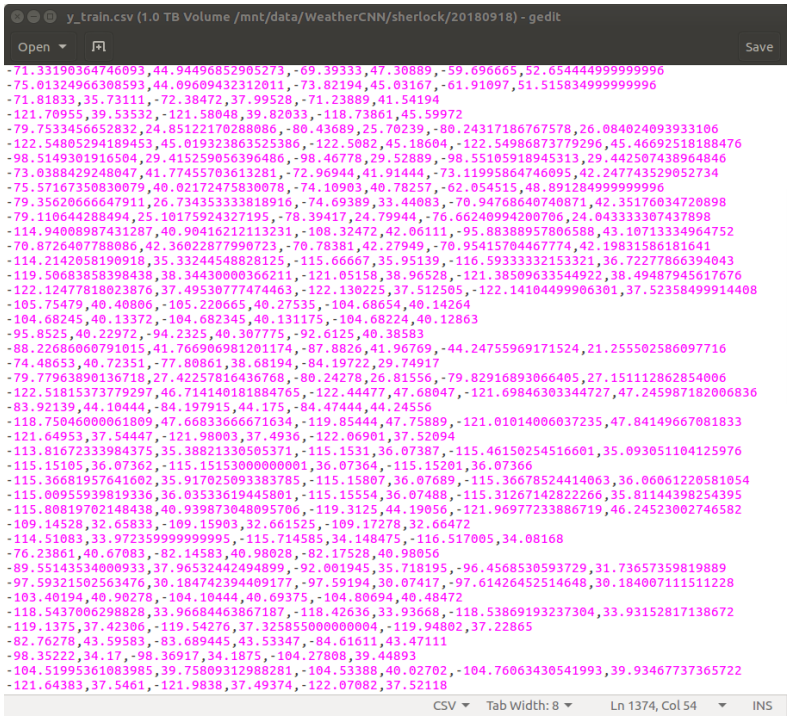
```
1: Initial NATS Environment
2: for Row in CallSign do
3:     Get Flight Plan Coordinate from NATS
4:     for Point in Trajectory do
5:         Find Closest Waypoint in the Flight Plan Coordinates
6:         Calculate Maximum Deviation
7:         if Maximum Deviation Exceed Threshold then
8:             return  Corresponding Waypoint, Point
9:         end if
10:        Merge Waypoint if needed
11:    end for
12:    Find Indices of Latitude and Longitude Based on Waypoint Returned
13:    Extend Labels
14:    Save Point who has Maximum Distance as Y train
15:    Call CIWS Parser to save X train
16:    Reload FAA Engine
17: end for
```

Outcome

X train comes with a set of numpy arrays and Y train contains the coordinates of three waypoints each row.



(a) X train



(b) Y train

Figure: Data Format

Plot

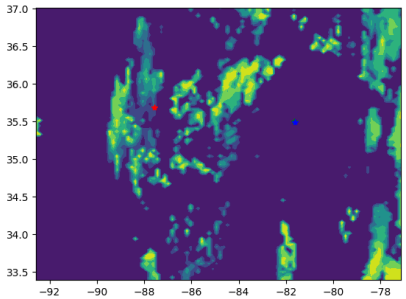


Figure: a

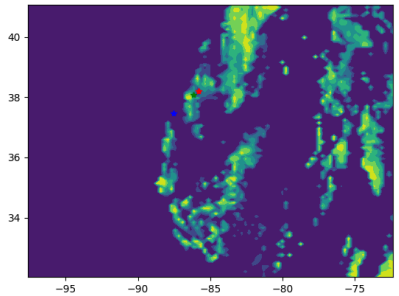


Figure: b

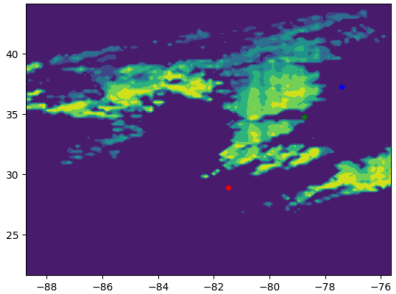


Figure: c

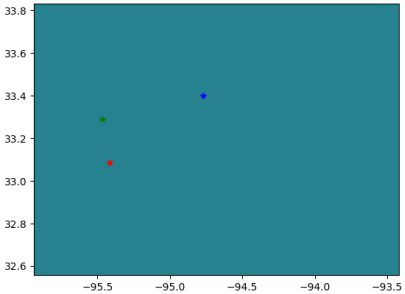


Figure: d

The pattern is not clear.

Future Work

Due to this issue, there is still a few thing to modify,

- Change the weather data search algorithm
- Process VIL data
- Train the model using current dataset

References

Clifford, S.F., et al.

Weather Forecasting Accuracy for FAA Traffic Flow Management

The National Academies Press, Washington, DC, 2003, pp. 2.

Erzberger, Heinz and Lauderdale, Todd A and Chu, Yung-Cheng.

Automated conflict resolution, arrival management and weather avoidance for ATM

27th International Congress of the Aeronautical Sciences, Nice, France, 19-24

D.Klingle-Wilson and J.Evans.

Description of the Corridor Integrated Weather System (CIWS) Weather Products

Project Report Prepared for the FAA, Washington, DC.

End