

Confidence Factor Variations for Aerial Threat Perception

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Abstract—This paper presents confidence factor variations for simulated threat perception architecture contributing a better way to quantify the results for threat perception accuracy. Our technique incorporates using data mining algorithms to find effective data patterns and matching the flight parameters with these patterns to give a percentage match. A confidence criterion is proposed to depict these results effectively and show variations for aerial threat prediction. We conclude that maximum confidence percentage can be achieved by using the maximum confidence factors. Each confidence factor returns maximum confidence when offsets and increments close to zero which is the ideal match brings the return.

Indexed Terms—Aerial Threat Confidence, Aerial Architecture Confidence, Confidence factor Variation, Threat Perception Confidence.

I. INTRODUCTION

Every country is conscious and vigilant about the threats to its airspace. And wants to keep an eye on the Air movement because of which Aerial threat perception is of grave importance to any nation. It has major applications in military where in competition with the enemy whoever has the first hand knowledge gains the air superiority.

Many measures like using paint coatings at thick edges of the plane, tilting different angles of the planes etc. are used to avoid getting into the enemy radars [1]. On the counter side ground forces use multiple techniques like low frequency radar transmitters, Infrared images etc. to detect planes via multiple sources [2].

II. METHODOLOGY

We need to have some principal classification identifiers for the threat perception that can help us in maintaining a unique signature for every plane. For this reason and for scalability we find as much factor as we can for the planes. Some of the direct identifiers include Radar Cross section size and some of the indirect identifiers like speed, ferry and combat ranges, zero fuel weight, thrust to weight ratio etc. There's got to be something unique about each plane that helps to identify it [3]. For that matter a signature of the plane is necessary. At this point in time our focus is to classify the results on a broad level of fighter, transporter, helicopter and bomber.

Some of the major factors that can act as principal classification identifiers include Speed of the plane, ceiling of the plane i.e. height from the surface of earth, heat signature

i.e. the heat radiated from different parts of the plane, radar cross section [4, 5] which is the blip size on the cross section of the radar feed and flight plans that are the flight schedules already decided. Our research incorporates speed and ceiling for now and makes the decisions using these two as classification criteria. We used the data mining C4.5 [6, 7] for classification because it helps building non-binary trees containing multiple branches.

The data mining algorithm gave us some of very useful patterns from the knowledge base. Like in one case it tells us that a Speed of plane less than 335 km/hr is a helicopter in general while a speed greater than 335 km/hr needs to be divided on the base of ceiling criteria where a ceiling of less than 13,716 meters is a transport and greater than that are fighters.

When we have the classification identifiers, classification groups and data mining approach selected we built architecture [8] for collecting the results.

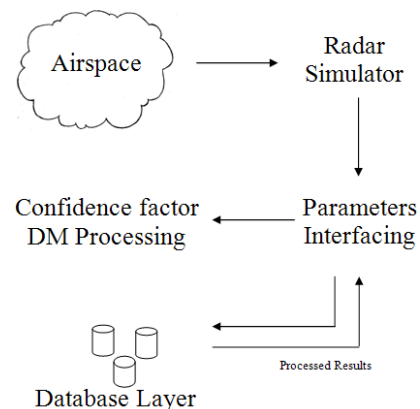


Fig. 1. Process flow for Aerial threat Perception

This architecture uses the mixture of many confidence factors for the prediction. We use the simulator for flight simulator to keep all the flight parameters to a file. Next we filter out values from the file for parameters that we are interested in which in this case are speed and ceiling. We transport these parameters over a UDP port to the database layer for necessary processing. While transporting we make XML strings first and convert them to bytes and the reverse follows at the database layer. There are two reasons for making XML strings and converting to bytes. Firstly, all the communication flow is in XML strings hence saving the time to write and read from files. Secondly, converting to bytes help in reducing the network traffic as well the communication between different programming languages is catered through this [9].

The database layer returns two types of result. One is the confidence factor for the matching results of the flight dumps with the knowledge base and the other is finding out the data

patterns from the knowledge base via Data Mining techniques [10] using the principal classification identifiers.

III. RESULTS

The results for the confidence factor are based on how accurately the flight dump values match with the knowledge base. Confidence factor is made of the following weighted factors:

- Radar Cross Section – 25%
- Heat Signatures – 25%
- Speed – 20%
- Ceiling – 20%
- Flight Plans – 10%

The relative weights are assigned according to the importance of a factor to the whole percentage. Radar Cross Section and Heat Signatures directly imply results based on what is seen i.e. the shape of the plane where as Speed and Ceiling are indirect measures and their results are implied. There can be a degree of error associated with the Speed and Ceiling factors e.g. a fighter can dive in at a low ceiling and reduce its speed to look like a helicopter etc.

We keep a 10% offset of the Average values of a field and increment at 10% of the offset for Confidence factor variations. From the knowledge base we have 54 planes randomly classified into different classification categories of fighters, helicopters, bombers and transporters. The values for Speed (km/hr) and Ceiling (meters) for these planes are given in Table 1.

TABLE 1: CEILING AND SPEED FROM KNOWLEDGE BASE

Number	Speed (Km/hr)	Ceiling (Meters)
1	1885	14000
2	2490	17300
3	682	9448.8
4	592	7000
5	210	3200
6	335	4500
7	2328	19812
8	993	20000
9	1960	18000
10	2450	18000
11	2205	16700
12	2333	17060
13	2205	15000
14	2450	16800
15	2205	16500
16	2756	18013
17	2756	17500
18	2756	18000
19	2450	16800
20	2045	18288
21	2450	19810
22	2695	18000
23	850	11000
24	932	10600
25	830	13716
26	878	-
27	901	-
28	871	-
29	865	-

30	1103	-
31	876	11300
32	950	13140
33	982	-
34	381	7300
35	903	-
36	592	7000
37	570	7000
38	1000	15000
39	224	4115
40	287	4770
41	260	5698
42	259	6096
43	222	4575
44	282	4875
45	270	5180
46	240	4500
47	238	5280
48	259	3048
49	282	5700
50	267	6096
51	282	4875
52	282	5700
53	280	8382
54	260	5200
Sum	60909	519877.8

Average Speed = $60909/54 = 1127.94$ km/hr

Offset at 10% of Speed = 112.79 km/hr

Increment at 20% offset = 22.55 km/hr

Average Ceiling = $519877.8/54 = 9627.36$ meters

Offset at 10% of Ceiling = 962.73 km/hr

Increment at 20% offset = 192.54 km/hr

Now that we have the Offset and Increment factors we will use them to find the Confidence factor variations. To start with we compare the related tagged values from the flight parameters with 0 offset to find if we have an exact match in our knowledge base, this gives us the maximum confidence percentage. If we don't have a match we use the rounded off $\pm 10\%$ ceiling (upper value) offset to find the match in a range. We then continuously keep incrementing the offset at 20% ceiling (upper value) of offset till we have an exact match. Table 2 shows some illustration for such cases.

We used some random values for the speed and ceiling in table 2 to find out how our variations for the confidence factor behave. Base value for the offset is $\pm 10\%$ ceiling (upper value) for ceiling and speed factors which in our case is 970 meters and 120 km/hr respectively.

We have 8 cases a-e for each scenario with decreasing confidence factor. Case a uses the 0 offset values for both speed and ceiling hence the maximum confidence is 40%. Case b and c use only one offset either speed or ceiling hence equal confidence factors. Rest of the cases constantly increment at $\pm 20\%$ ceiling (upper value) of the offset, which in our case is 30 km/hr and 970 meters for speed and ceiling respectively.

Once we have a match we neglect rest of the cases. Scenario 1 shows that we have a match at 35% confidence i.e. within the range 9530 – 11470 meters for ceiling. There is an AND condition between the speed and ceiling parameters

hence both the conditions have to be met for any particular confidence level which in this case is 876 km/hr for speed. Figure 2 shows the matching values from the knowledge base for Case 1.

TABLE 2: CONFIDENCE FACTOR VARIATIONS. SP REPRESENTS SPEED, CE – CEILING, SO - SPEED OFFSET, CO - CEILING OFFSET, CF – CONFIDENCE FACTOR

S. No	Case	SP	CE	SO	CO	Results	CF
1	a	876	10500	0	0	No Match	40%
	b	876	10500	0	970	Match	35%
	c	876	10500	120	0	Neglected	35%
	d	876	10500	120	970	Neglected	30%
	e	876	10500	150	1170	Neglected	25%
	f	876	10500	180	1370	Neglected	20%
	g	876	10500	210	1570	Neglected	15%
	h	876	10500	240	1770	Neglected	10%
2	a	880	10500	0	0	No Match	40%
	b	880	10500	0	970	No Match	35%
	c	880	10500	120	0	No Match	35%
	d	880	10500	120	970	Match	30%
3	a	220	5000	0	0	No Match	40%
	b	220	5000	0	970	No Match	35%
	c	220	5000	120	0	No Match	35%
	d	220	5000	120	970	Match	30%
4	a	1950	15500	0	0	No Match	40%
	b	1950	15500	0	970	No Match	35%
	c	1950	15500	120	0	No Match	35%
	d	1950	15500	120	970	No Match	30%
	e	1950	15500	150	1170	No Match	25%
	f	1950	15500	180	1370	No Match	20%
	g	1950	15500	210	1570	Match	15%
5	a	2450	16800	0	0	Match	40%
	b	2450	16800	0	970	Neglected	35%
	c	2450	16800	120	0	Neglected	35%

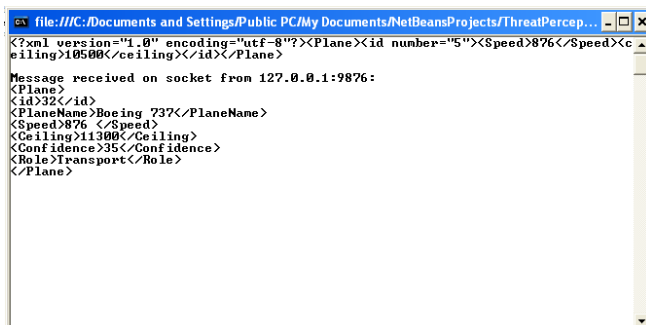


Fig. 2. Return knowledge base values for the Confidence factor

Case 2 and 3 give a confidence factor of 30 %, case 4 gives 15% whereas case 5 is an exact match and gives 40% confidence.

IV. CONCLUSION

The purpose of this work is to quantify and present a better way to measure results. We used a simulated environment to generate the flight parameters and matched them against the knowledge base. To measure the effectiveness of our decisions we presented architecture to measure results where we introduced offsets and increments to the offsets and measured the confidence factor effectiveness based on these variations. To achieve a better confidence more and more confidence factors with offsets close to zero needs to be achieved.

Future enhancements can use this work with the live radar feed from the airspace. Another application for this work can be a control system where weapons are assigned based on the confidence achieved and target identification.

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