Space Group Formation Based on Attribute Value for Maneuvering Target

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Summary

New group formation algorithm for maneuvering target was proposed. The algorithm defined multiple key property similarities by extracting the results of level 1 processing of data fusion and re-fused them to calculate the group formation. It accomplished group formation in real time at multi-levels with lower calculation complexity. Due to the fact that uncertainty of measurement space had been mapped to the fuzzy similarity space, the uncertainty of measurement space was resolved using fuzzy match mechanism. In addition it was a reliable approach for space group formation and event detection in battlefield. Simulation results showed that it was efficient to generate group formation for maneuvering target in situation assessment. The time complexity of the algorithm was only O (n^2). This approach can be also widely used to solve cluster problem for other types maneuvering target.

Key words:

Maneuvering target, space group formation, situation assessment, clustering procedure

Introduction

Major multi-sensor data fusion functions include level 1 processing, level 2 processing, and level 3 processing. Level 1 processing combines positional and identity data from multiple sensors to establish a database of identified entities, target tracks, and uncorrelated raw data. Level 2 processing, or situation assessment, seeks a higher level of inference above level 1 processing. It aims to assess the meaning or patterns in the order of battle data.

The foundation of group formation is to group available data and exposures the relations of situation elements, as well as displays all interested features that attached to all elements [1]. In fact, the whole process is to do data mining in observation domain. Based on this process, situation element is acquired and the deep cognition of situation in current airspace is generated.

Conventional group formation for maneuvering target is done artificially. Some research work has carried out in relation type of group formation for maneuvering targets in situation assessment. Fox example, Ref. [2] defined relation type as couple, attack etc., and took them as the basic of situation discriminating. Ref. [3] defined relation of maneuvering targets as multi-kinematics connection, which includes lead, package, engagement etc. Ref. [4] applied the MFA algorithm to group formation for maneuvering targets. However, all these work are hard to be used in real work, for they hadn't considered doing group formation at multi-time-steps.

This paper proposes a novel group formation algorithm for maneuvering. The algorithm defines multiple key property similarities by extracting the results of level 1 processing and re-fuses them to calculate the group formation. It can accomplish group formation in real time at multi-levels with lower calculation complexity.

2. Theories for Space Group Formation Algorithm

In this paper, situation assessment is defined in two levels:

1) Target point: in our research, target point is a minimum unit platform which airborne radar can distinguish their air route and obtain their property parameters in airspace. For example, it may be a flight formation, a plane, or a guided missile.
2) Space group: It includes multiple targets which have similar properties and are close to each other during an observation period, and it could be considered as belonging to different levels needed. For example, a formation is a fight cluster composed of some planes or units, which can keep certain fore-and-aft and right-and-left distance and altitude difference among them. So a formation is a kind of low-level (fine granularity) space group [5].

The space group formation is dynamic cluster analysis for observed airspace according to specific property. The main problem of cluster algorithm is to give suitable measurement and calculation method for distance of elements. As the situation of maneuver target changes continually in a fusion cycle, the clustering data is a time series.

All individuals in a space group consequentially belong to same-side target point (red force, blue force or neutral force). The situation property of target point is a kind of time serial data, which is defined as:

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Definition 1: A target point *a* is an *n*-tuple containing *l*-length track and multiple target properties. Let τ be scan period time and $T=l\tau$ be fusion period, the property sets of *a* is equal to { $id,(x,y,z, v_x,v_y,v_z, \Psi_s, \beta, \gamma_s)_{0\tau}$,… $(x, y, z, v_x, v_y, v_z, \Psi_s, \beta, \gamma_s)_{i\tau}$,…… $(x,y,z,v_x, v_y, v_z, \Psi_s, \beta, \gamma_s)_{l\tau}$, *Attr*, *type*, *Other* }.

Where *id* represents the number of target point, $(x, y, z, v_x, v_y, v_z, \Psi_s, \beta, \gamma_s)_{i\tau}$ represents the basic state data of target point *a* in a sampling period. *x,y,z* are position of an aircraft in ground reference frame, *y* is flying altitude. Ψ_s, β, γ_s are yaw angle, tilt angle and roll angle. *Attr* represents the property of hostile and friendly ("0" represents red force, "1" represents blue force and "2" represents neutral force), *type* represents the plane type information, such as acceleration data, radiant source information, departure airfield, and so on.

In real fusion, not all of above information can be obtained. In addition it has deviation as a result of sensor performance limitation. The information used in this paper only included the basic situation data of target point and the property information of red force and blue force.

Let *sim* be the similarity operator. $sim_\Omega(a,b)$ represents the similar degree of target point *a* and *b*, which are similar based on the feature set Ω. $sim_\Omega(a,b) \in [0,1]$. The calculation of classification similarity and the fusion method of collectivity similarity for different target point properties will be described in later section.

Definition 2: Let *S* be observational airspace in time $[t_p, t_q]$. *Y* is target point set in S. If $\exists\ \gamma \in Y$, and $\forall\ \gamma_i \in \gamma$, in recent *l* sampling-periods and spatial property set Ω_1 of target points, the similarity between $\exists\ \gamma_i \in \gamma$ and γ_i is $sim_{\Omega 1}(\gamma_i, \gamma_j) \geqslant h$, where *h* is a given threshold. Then γ is called a space group under *h*.

Therefore, the space group γ can be mapped to a kind of binary relation defined in a similarity distance at a certain time t_j. This relation is called as group formation relation.

Theorem 1: The group formation relation is an equivalence relation.

Proof: Let *R* represents a group formation relation in the space group γ, then *aRb* can be obtained because of *a*, *b* $\in \gamma$, vice versa. It is obviously that group formation relation is reflexive and symmetrical. Let *c* be another target point in the airspace, if there is *bRc*, there will be *b* $\in \gamma$ inevitably, and *aRc* is obtained. Therefore *R* provides with transitivity. So *R* is equivalence relation.

3. Similarity Examinations

Level 1 processing can provide situation estimation and property estimate information for target. First of all, we extract and analyze the feature parameter of targets at the level 1 processing, and define multiple key property similarities to measure behavior feature of the targets. Further more, according to logic operation to multiple target property and behavior similarities, the synthesis similarity among targets is obtained, which is the measure criterion for group formation.

Definition 3: The identity similarity between two target points *a* and *b* is defined as $sim_\perp(a,b)$, $\perp$ represents the set of identity properties of the target point, and $sim_\perp(a,b) \in [0,1]$.

The identity similarity can be obtained by fusing feature of radiant source from target points and information of IFF sensors and others.

Definition 4: The position difference between two target points *a*, *b* is defined as $d(a,b)$, which is determined by the difference of aircraft projective distance and the altitude difference. Therefore it can be calculated by formula $d(a,b) = ((x_a - x_b)^2 + (z_a - z_b)^2)^{1/2} + \beta \bullet |y_a - y_b|$. Here β is the ratio of the importance of flying altitude difference and the aircraft projective distance difference in judgment to which group the target belongs.

Definition 5: The position similarity between two target points *a* and *b* is defined as $sim_\parallel(a,b)$. $\parallel$ is the position attribute among target points. According to experience, the definition of $sim_\parallel(a,b)$ is the fuzzy relations of fall half normal distribution:

$$sim_\parallel(a,b) = \begin{cases} 1 & 0 \le d(a,b) \le \varepsilon \\ e^{-k_1(d(a,b)-\varepsilon)^2}, & d(a,b) > \varepsilon, k_1 > 0 \end{cases}$$

Here ε is the threshold of position difference between two target points. It's a normal formation distance between two neighboring target points in the same altitude. In periods *l*,

$$sim_\parallel(a,b) = \sum_{i=1}^{l} sim_{\parallel i}(a,b)/l \ .$$

From above definitions we can see that identity similarity indicates the possibility degree when two target points ascribed to same force; position similarity indicates close degree of two-target point's position in multiple track periods. However, it is not reliable enough to judge space group formation of two target points based on these two similarities. For example, suppose an aircraft in flight formation flights conversely, it still satisfies the above two similarities in tracking periods *l*. Obviously a conversely flying aircraft cannot be part of the group. So it is necessary to define the velocity similarity $sim_{\triangle}(a,b)$.

Definition 6: The relative velocity difference between two target points *a* and *b* is defined as *Cv*(*a*,*b*). *Cv*(*a*,*b*) =|*v*(a)-*v*(b)|/ |*v*(a)-*v*(b)|. *Cv* can perfectly express the prominent degree about the velocity difference of two target points relative to current velocity of the target point.

Definition 7: The velocity similarity between two target points *a* and *b* is defined as $sim_{\triangle}(a,b)$. Where △ is the set of velocity properties of two target points. Let *Cv*(*a*,*b*) be relative velocity coefficient of the two target points, σ be proportion factor, then $sim_{\triangle}(a,b)$ is defined as the fuzzy relations of fall half normal distribution:

$$sim_{\Delta}(a,b)=\begin{cases}1 & 0\le Cv(a,b)\le\sigma\\ e^{-k_2(Cv(a,b)-\sigma)^2}, & Cv(a,b)>\sigma, k_2>0\end{cases}$$

Where $Cv(a,b)=(|v_x(a)-v_x(b)|+|v_y(a)-v_y(b)|+|v_z(a)-v_z(b)|)/(|v_x(a)+v_x(b)|+|v_y(a)+v_y(b)|+|v_z(a)+v_z(b)|)$.

In period *l*, the velocity similarity between two target points *a* and *b* is:

$$sim_{\Delta}(a,b)=\sum_{i=1}^{l} sim_{\Delta_i}(a,b)/l\ .$$

If all of above three similarities between two target points are higher than threshold *h*, the two target points take as members of the same space group.

4. Space Group Formation Algorithms

The process of space group formation is based on definitions in Section 3. Let *S* be current observed airspace, and the set of target point is *X* (*X* ∈*S*). The formation of a space group can be regarded as a process of fine granularity cluster under a certain threshold in *S*. The calculation steps are described as follows.

1) $sim_{\perp}(X)$ is obtained by identity recognition result, which is a symmetrical matrix and only upper half matrix need to be calculated. Identity similar relation is a kind of equivalence relation, which can divide the target into blue force, red force, and neutral force.
2) Calculate $sim_{|}(X)$, especially only calculate the upper half matrix according to definition 5.
3) Calculate $sim_{\triangle}(X)$, especially only calculate the upper half matrix according to definition 7.
4) Calculate $sim_{\Omega}(X)$. $sim_{\Omega}(X)= sim_{\perp}(X)\wedge sim_{|}(X)\wedge sim_{\triangle}(X)$, $sim_{\Omega}(X)_{ij}\in[0,1]$.
5) Convert $sim_{\Omega}(X)$ to BOOL matrix *P*. Let *h* be the threshold value of group formation, *P* is defined as:
6) Calculate the connective path of matrix *P* and obtain group formation results, includes two steps:
   a. Create undirected graph *G* (*V*, *E*). *V* is *n* elements of target point set *X*; the edge (*u*,*v*)∈*E*, if and only if $P_{ij}=1$;
   b. Call algorithms of connective branch of undirection graph, and obtain connective branch of *G* (*V*, *E*). The vertex set of every connective branch of *G* (*V*, *E*) is the fuzzy cluster set that required.

The time complexity of basic fuzzy cluster algorithms is known as $O(n^3 log n)$. However, all three similar relations of *n* target points can be represented by $m=1/2\cdot n(n-1)$ 2-tuples, the time complex in step 1), 2), 3), will not exceed $O(m\times l)$ in periods *l*. Thus the time complexity of algorithms in this paper won't exceed $O(m\times l)$. In above steps, as m=|E| and *l* is a constant, the time complexity won't exceed $O(l\times|E|)$ in step 1),2),3) and the time complexity is $O(|E|)$ in step 1),2),3).

The time complexity is $O(|E|)$ in step 4), 5). As undirected graph G can be represented by 2×*m* edges in edge adjacency table of graph, the time complexity of 6) a is also $O(|E|)$. As well as, the time complexity of 6) b is also $O(|E|)$.

In conclusion, the algorithm time complexity is $T(n) = O(|E|)$. Where $|E|=1/2\cdot n(n-1)$, and $n\le |E|\le n^2$.

5. Simulation Experiments

In order to evaluate the validity of the algorithms, we assume a simulation movement of maneuvering targets like Fig.1. The movement type and the simulation data are generated from the following flight control equation [6]:

$$\begin{cases}\dfrac{dV}{dt}=g(\eta_x-\sin\theta) & (1)\\ \dfrac{d\theta}{dt}=(g/v)(\eta_y\cos\gamma_s-\cos\theta) & (2)\\ \dfrac{d\varphi_s}{dt}=-(g/v)(\eta_y\sin\gamma_s/\cos\theta) & (3)\end{cases}$$

$$\begin{cases} \dfrac{dX_d}{dt} = V\cos\theta\cos\varphi_s & (4) \\ \dfrac{dY_d}{dt} = V\sin\theta & (5) \\ \dfrac{dZ_d}{dt} = -V\cos\theta\sin\varphi_s & (6) \end{cases}$$

Where $\varphi_s, \theta, \gamma_s$ respectively denote the yaw angle, tilt angle and roll angle of an aircraft track. X_d, Y_d, Z_d are projective position of the aircraft in three axis of reference frame. g is gravity acceleration, V is velocity vector, t is current time. η_x , η_y are respectively the tangential overload and the vertical overload. In the simulation of aircraft maneuvering flight, η_x and η act as movement controlling parameter. Each of the targets takes linear flight as its initial state.

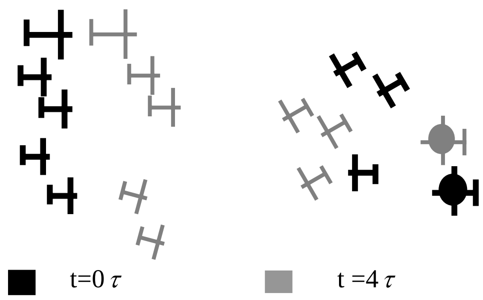

Fig. 1 The battlefield situation in t= 0~$l\tau$.

The simulation time in Fig. 2 is 20*s* (the periods of each step τ =5, the number of steps l=4). In our simulation scenario, (1) is a third-side aircraft; (2), (3) are two red-side formations which carried out the same mission, (4), (5) are two red-side formations carrying out another mission. These two mission is grouped to two formations at t=0 τ . (6) (7) are two air interception formations of blue-side coming from the same airfield. (8) is a blue-side air interception formation coming from another airfield. (9) Is a early warning aircraft of the blue-side.

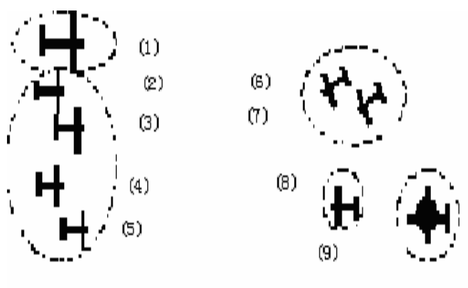

Fig. 2 The space group formation result at t=*0* τ .

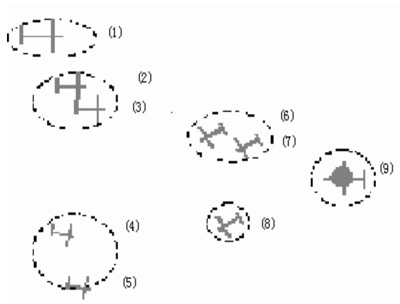

Fig. 3 The space group formation result at t=$l\tau$.

All targets are grouped again after 4 time-steps simulation using our space group formation algorithm. Under a certain threshold, the set of space group formation is obtained as {{1}, {2, 3}, {4, 5}, {6, 7}, {8}, {9}}. That is coincident with real observed result.

Table 1: Parameter Value of Multiple Similarities

PARAMETER	HYPOTAXIS	VALUE
K_1	$sim_{|}(X)$	1.0
ε	$sim_{|}(X)$	0.3
β	$sim_{|}(X)$	5.0
K_2	$sim_{\triangle}(a,b)$	4.0
σ	$sim_{\triangle}(a,b)$	0.005
h	*Threshold value of group formation*	0.75

The parameter setting of each similarity definition is depicted in Table I, the group formation results of initial state is depicted in Fig.2, and the space group formation results after 4 steps is depicted in Fig 3.In the simulation, the red force group {2,3,4,5} that have been grouped in batches is found. Where (4), (5) make a large maneuvering turning, blue force (6), (7) hold the original direction. (8) Merges into same group with {6, 7} and takes same direction. (9) Keeps turning in near airspace.

6. Conclusions

The main results of our study are:

1) Our algorithm can process the time series of maneuvering target position variation and release group formation dynamically, which provided a feasible way for maneuvering target grouping and calculated the relative results directly.
2) The time complexity of our algorithm is only $O(n^2)$. The simulation experiment shows that this algorithm has higher efficiency and the results are credible.
3) It is fatal to get a certain threshold and apply it in the calculation of multiple key property similarities. So it needs to determine by experts according to real condition.

4) In appendix there are important middle results.

Appendix: Some Important Middle Results

Position Difference Matrix

0	25.2043	25.1911	25.6977	26.3556	52.6766	52.7012	48.0780	86.1400
0	0	0.2003	1.3172	1.9855	38.9909	39.0006	37.4529	76.7742
0	0	0	1.2795	1.9275	38.9986	39.0082	37.5583	76.7883
0	0	0	0	0.8325	40.0120	40.0208	38.4376	77.9209
0	0	0	0	0	40.0705	40.0783	38.4809	78.0872
0	0	0	0	0	0	0.0827	5.2281	40.2403
0	0	0	0	0	0	0	5.1806	40.1966
0	0	0	0	0	0	0	0	44.0386
0	0	0	0	0	0	0	0	0

Relative Velocity Difference Matrix Cv

0	0.3179	0.3238	0.3492	0.3367	4.5828	4.5880	8.1125	5.5978
0	0	0.0078	0.2378	0.2270	5.2673	5.3026	5.3237	6.1248
0	0	0	0.2376	0.2273	5.2252	5.2599	5.3290	6.1139
0	0	0	0	0.0140	4.0373	4.0447	32.2457	11.2793
0	0	0	0	0	4.0835	4.0911	32.3003	11.2341
0	0	0	0	0	0	0.0013	0.1769	0.3342
0	0	0	0	0	0	0	0.1766	0.3336
0	0	0	0	0	0	0	0	0.3354
0	0	0	0	0	0	0	0	0

Position Similarity Matrix

0	0.0000	0.0000	0.0000	0.0000	0	0	0	0
0	0	1.0000	0.3553	0.0584	0	0	0	0
0	0	0	0.3831	0.0707	0	0	0	0
0	0	0	0	0.7531	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1.0000	0.0000	0
0	0	0	0	0	0	0	0.0000	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

Velocity Similarity Matrix

0	0.6760	0.6660	0.6226	0.6440	0.0000	0.0000	0.0000	0.0000
0	0	1.0000	0.8051	0.8211	0.0000	0.0000	0.0000	0.0000
0	0	0	0.8054	0.8206	0.0000	0.0000	0.0000	0.0000
0	0	0	0	0.9997	0.0000	0.0000	0	0.0000
0	0	0	0	0	0.0000	0.0000	0	0.0000
0	0	0	0	0	0	1.0000	0.8885	0.6482
0	0	0	0	0	0	0	0.8889	0.6493
0	0	0	0	0	0	0	0	0.6462
0	0	0	0	0	0	0	0	0

Identity Similarity Matrix (given)

0	0	0	0	0	0	0	0	0
0	0	1	1	1	0	0	0	0
0	0	0	1	1	0	0	0	0

0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	1	1
0	0	0	0	0	0	0	1	1
0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0

Synthesized group similarity matrix

0	0	0	0	0	0	0	0	0
0	0	1.0000	0.3553	0.0584	0	0	0	0
0	0	0	0.3831	0.0707	0	0	0	0
0	0	0	0	0.7531	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1.0000	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

BOOL Matrix (h=0.75)

0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

Simulating Values of Parameter on Scenarios for Experiment

NO.	t=0 τ	t=1 τ	t=2 τ	t=3 τ	t=4 τ	Maneuvering Manner	Attribute	Practice Value
	State: ***P***=(x, y, z),Speed: ***V***=(v_x, v_y, v_z),Initial angle ***A***=(φ_s, θ);Control parameter: ***C***=(η_x, η_y, γ_s)							
1	***P***=(3.000, 2.000, 30.000) ***V***= (0.280, 0, 0);***A***=(0, 0);	***P***=(4.4006, 1.9877,30.002),***V***= (0.281, -0. 0049,0.001);	***P***=(5.812, 1.950,30.009),***V***= (0.283,-0.0098, 0.0018);	***P***=(7.2027, 1.961,30.016) ***V***= (0.2829, 0.014, 0.001);	***P***=(8.630, 2.096,30.019) ***V***= (0.2764, 0.038, 0.0003);	Fly directly following x - axis	Center	Single transporter
	C=(0.015,0.9,0.02)(0~2 τ), (0.01, 1.5, -0.01) (2 τ ~4 τ)							
2	***P***=(3.022, 4.002,15.060) ***V***= (0.360, 0, 0); ***A***=(0, 0);	***P***=(4.801, 4.014,15.061); ***V***=(0.3597, 0.0048,0.00026)	***P***=(6.617, 4.051,15.063); ***V***=(0.3586, 0.0097,0.00054)	***P***=(8.409, 4.082,15.066); ***V***=(0.3584, 0.0024,0.00049)	***P***=(10.203, 4.075,15.068); ***V***=(0.359, -0.0049,0.00046)	Fly directly following x - axis	Red	Group of two Planes
	C=(0.001,1.1,0.005)(0~2 τ), (0.01, 0.85, -0.001) (2 τ ~4 τ)							
3	***P***=(3.060, 4.030,15.032) ***V***= (0.360, 0, 0); ***A***=(0, 0);	***P***=(4.819, 4.035,15.032); ***V***=(0.3599, 0.0024,0.0001);	***P***=(6.658, 4.054,15.033); ***V***=(0.3593, 0.0049,0.0002);	***P***=(8.456, 4.054,15.034) ***V***=(0.3596, -0.005,-0.0002)	***P***=(10.256, 4.005,15.035) ***V***=(0.3601, -0.014,-0.0001)	Fly directly following x - axis	Red	Group of two Planes
	C= (0.001 1.05 0.002) (0~2 τ), (0.005,0.8,-0.001) (2 τ ~4 τ)							

4	***P***=(3.000,4.000, 15.000); ***V***= (0.300, 0,0); ***A***=(0, 0);	***P***=(4.486,3.999,14.881); ***V***=(0.296, -0.000230,-0.04779)	***P***=(5.941,3.997,14.524); ***V***=(0.2848, -0.000462, -0.0946)	***P***=(7.321, 3.994,13.939); ***V***=(0.2660, -0.00069, -0.1390)	***P***=(8.597,3.991, 13.135); ***V***=(0.2403, -0.00092, -0.1801)	Fly directly following x – axis, then turn right in angle 30	Red	Single plane
	C= (0,1.4,-0.78) (t= 0s ~ 16.475s), (0,0.1,0) (t= 16.475s ~ 20s);							
5	***P***=(3.050,4.000, 14.080); ***V***= (0.300, 0,0); ***A***=(0, 0);	***P***=(4.530,3.997,13.959); ***V***=(0.296, -0.0001195, -0.04857)	***P***=(5.985,3.988,13.596); V=(0.2845, -0.0002402, -0.0963)	***P***=(7.363, 3.973,13.000); ***V***=(0.2654, -0.00036, -0.1416)	***P***=(8.681,3.961, 13.246); ***V***=(0.2610, -0.00011, -0.1504)	Fly directly following x – axis, then turn right in angle 30	Red	Single plane
	C= (0,1.4,-0.8) (t= 0s ~ 15.956s), (0,0.1,0) (t= 15.956s ~ 20s);							
6	***P***=(43.080,5.150, 17.155); ***A***=(-0.2618, 0);	***P***=(41.565, 5.150,16.790)	***P***=(40.048, 5.150,16.343	***P***=(38.532, 5.150,15.936)	***P***=(37.015, 5.150,15.530)	Fly smoothly in reverse angle 30 with x- axis, then turn right in angle 30	Blue	Group of two Planes
	t=0s~20s: ***V***= (-0.303, 0, -0.0813); ***C***=(0,1,0)							
7	***P***=(43.119, 5.145,17.114) ***A***=(-0.2600, 0);	***P***=(41.602, 5.145,16.711)	***P***=(40.084,5.145,16.307)	***P***=(38.567, 5.145,15.904)	***P***=(37.050, 5.145,15.500)	Fly smoothly in reverse angle 30 with x- axis, then turn right in angle 30	Blue	Group of two Planes
	t=0s~20s: ***V***= (-0.3034, 0, -0.08072); ***A***=(-0.2600, 0,0); ***C***=(0,1,0)							
8	***P***=(43.000,3.000, 16.000); ***V***= (-0.300, 0,0); ***A***=(0, 0);	***P***=(41.492, 3.398, 16.000), ***V***=(-0.301, 0.155,0)	***P***=(40.009, 4.434,16.000) ***V***=(-0.282, 0.186,0)	***P***=(38.554, 5.026,15.908) ***V***=(-0.308, 0.071,-0.052)	***P***=(37.035, 5.165,15.518) ***V***=(-0.304, -0.0012,-0.086)	Fly smoothly, Ascend. Adjust then turn swerve	Blue	Single plane
	C= (1,4,0) (0s~8.14s); (0,-2, 0) (8.14s~11.4s); (0,-2,0.78) (11.4s~17.4s); (0,-0.2,0.6)(17.4s~18.7s); (0 ,0.9, 0) (18.7s~20s)							
9	***P***=(80.000,5.000, 30.000); ***V***= (-0.314, 0,0); ***A***=(0, 0);	***P***=(78.501, 5.000, 30.063), ***V***=(-0.312, 0,0026416)	***P***=(76.945, 5.000,30.264) ***V***=(-0.3093, 0,0.05385)	***P***=(75.412, 5.000,30.601) ***V***=(-0.3034, 0,0.08088)	***P***=(73.849, 5.000,31.095) ***V***=(-0.2947, 0,-0.1084)	Fly smoothly, then hover	Blue	Early warning airplane
	C= (1, $\eta_y = \cos\theta / \cos\gamma_s$, 0) ; When t=0s, η_y =1.1295							

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