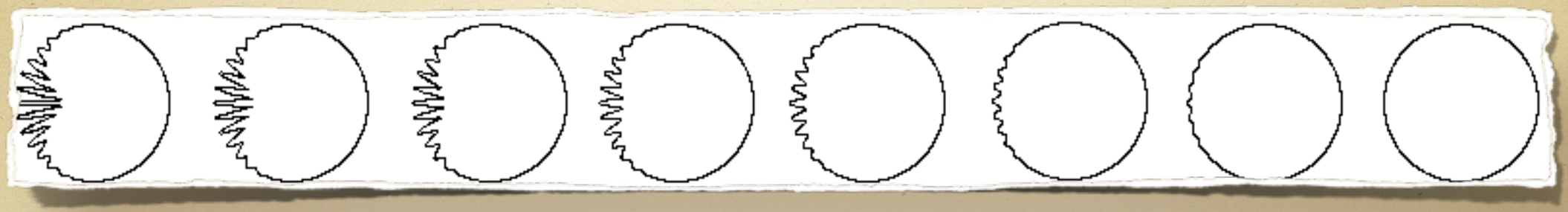

One principle for the identification of shape of an object

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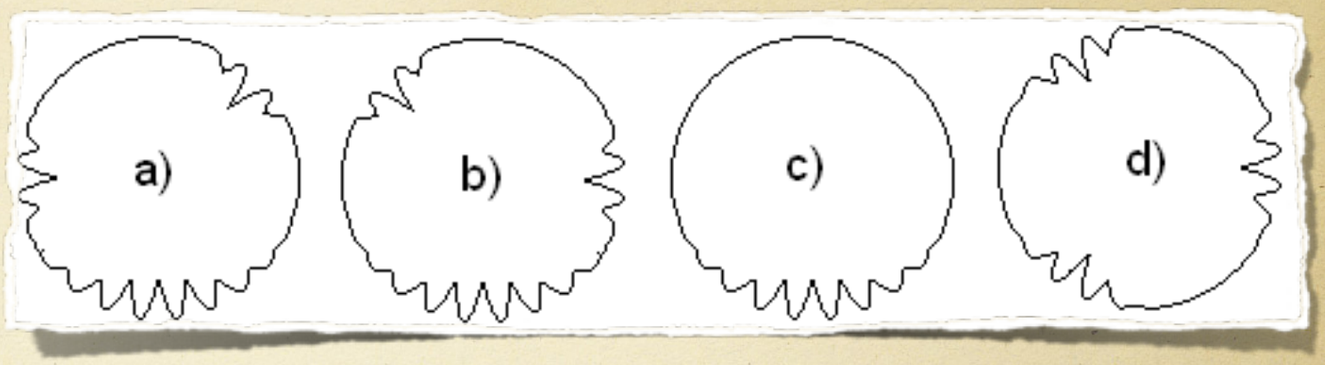
Peoples' Friendship University of Russia (RUDN University),

Moscow - Dubna 2017

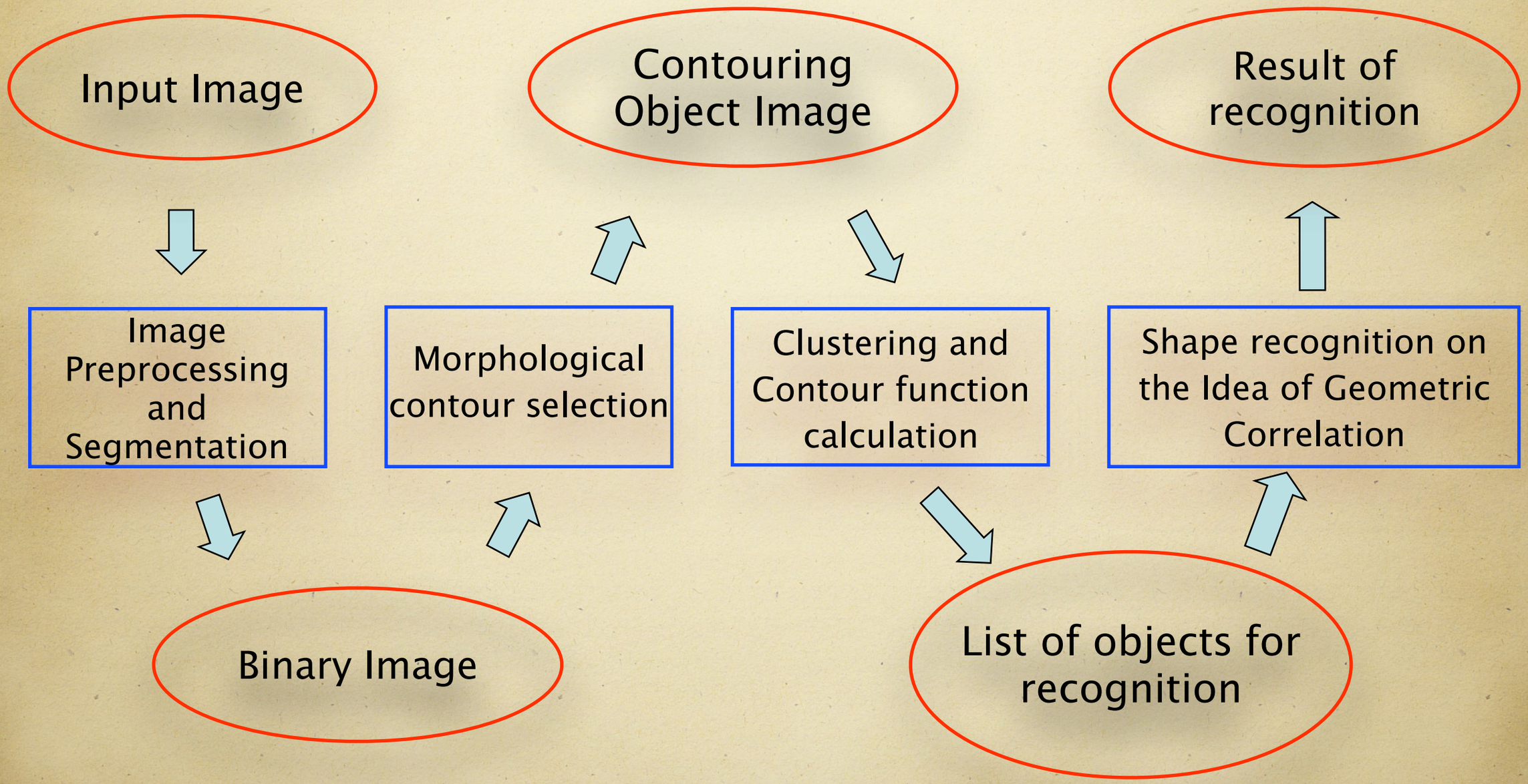
Main Goal of Research



The goal of research is *developing and modelling of methods of identification shapes of object;*

- ***Invariant to numerous group of geometric transformation;***
- ***Using optimal set of information descriptions;***
- ***Allow identification shape of object with apriory defined accuracy in automatic and semiautomatic mode in real time.***

One methodology on image processing and pattern recognition



Metrics of shape identification

For the last 20 years we have introduced the next metrics:

- Geometric correlation (18 modifications);
- Line correlation (6 modifications);
- Projective correlation (2 modifications)
- ***Correlation with incomplete information (now)***

Geometric correlation

Advantages

- ***High precision of pattern recognition of shape of object;***
- ***Low sensitivity to noise influence;***
- ***Invariance to 2d affine transformation (shift, zoom, rotation, mirror transformation);***
- ***Ability of identification in real time.***

Imperfections

- *Requirements to completeness of contour (signature analysis)*
- *Difficulties to receive full closed contours;*
- *Sensitivities to centre of mass shift of contour function.*

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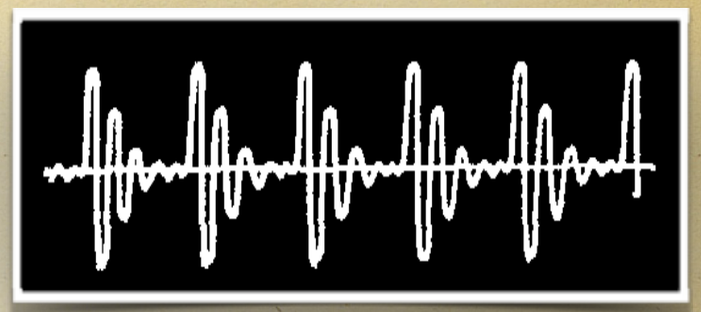
Information part of any curve



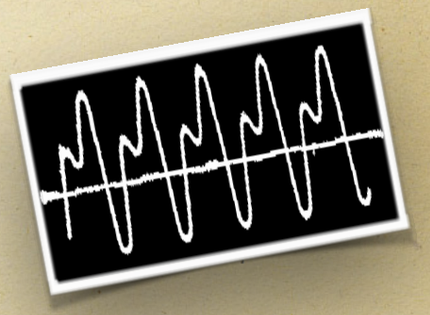
What can characterise any curve (function) in space from information point of view?

?

forever question

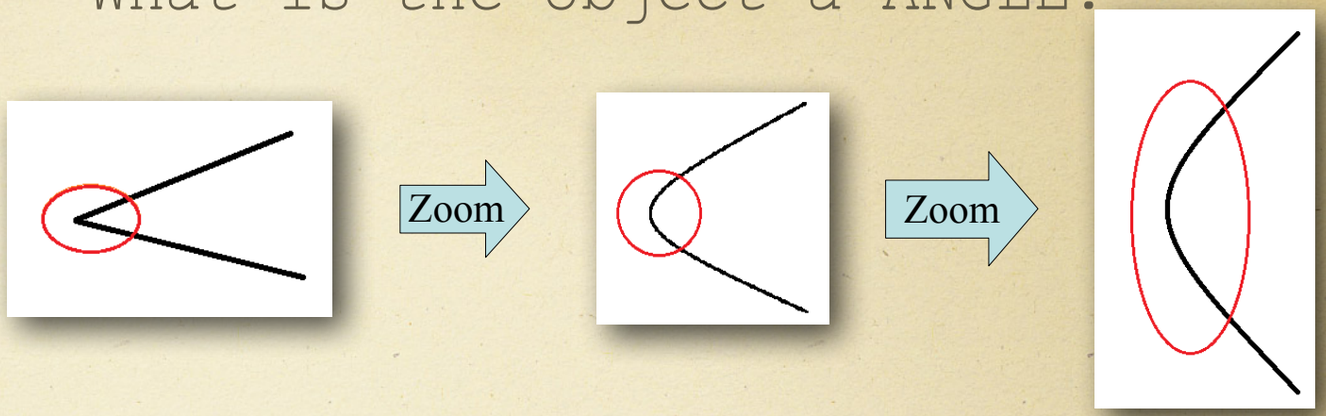
How we can compare two curves with:

- *different scale,*
- *in different time,*
- *arbitrary rotation,*
- *spatial shift and*
- *mirror transformation ?*



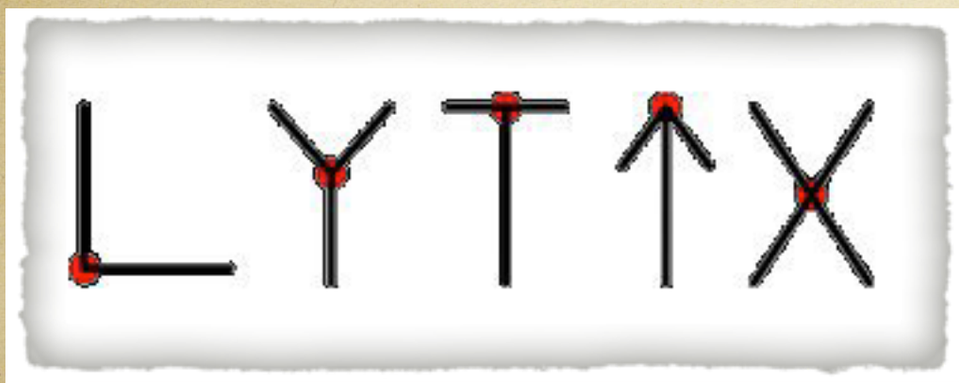
Angle Understanding

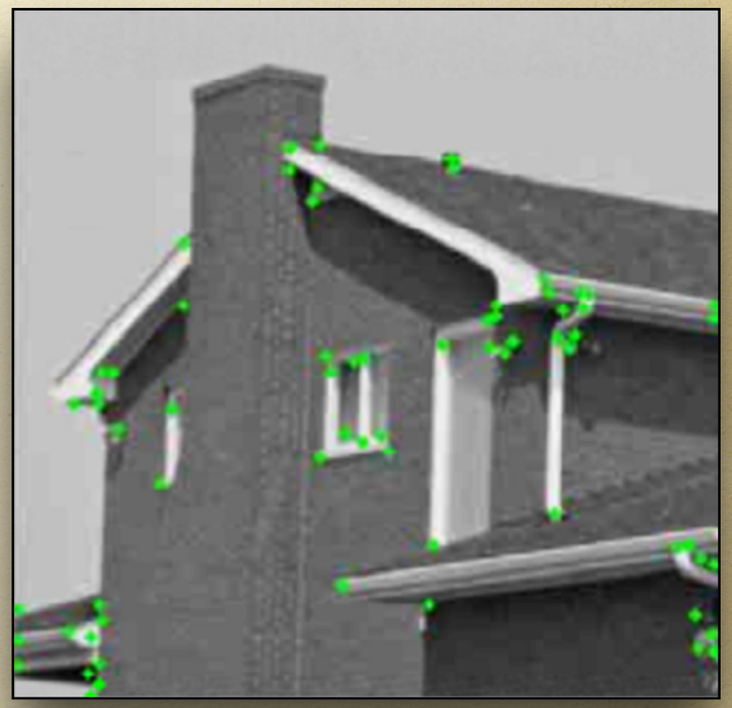
What is the object a ANGLE?



Properties:

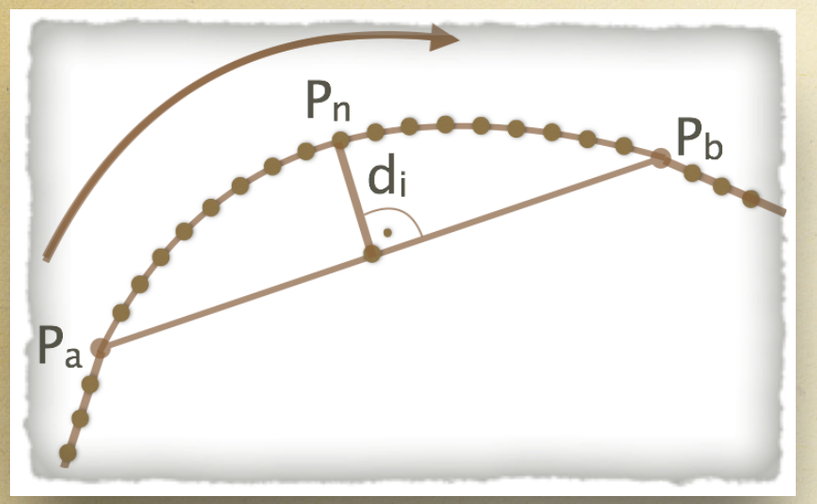
- Gradient of image have two dominant direction in area neighbour of angle.
- Angles is better differences.
- Angles have most information part of image under process identification shape of object in human vision.





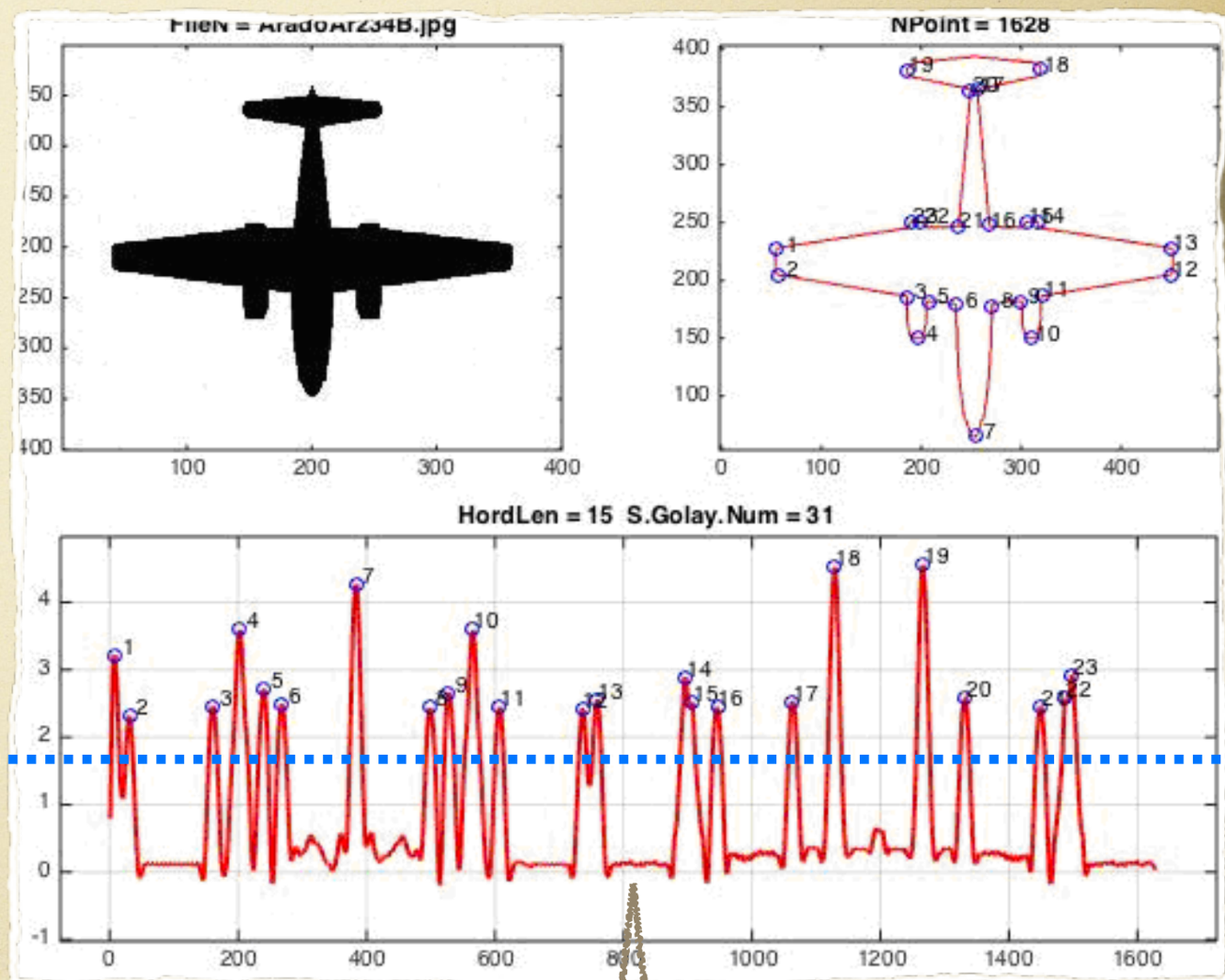
Harris Detector

Receive “angle” function



$$G_f = \{a = t_0 < t_1 < \ldots < t_l = b\},$$

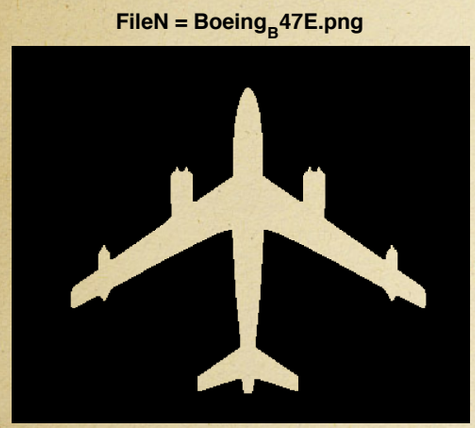
$$d_i = \sqrt{\frac{\left((x_i - x_a)(y_b - y_a) - (y_i - y_a)(x_b - x_a)\right)^2}{(x_a - x_b)^2 + (y_a - y_b)^2}}$$

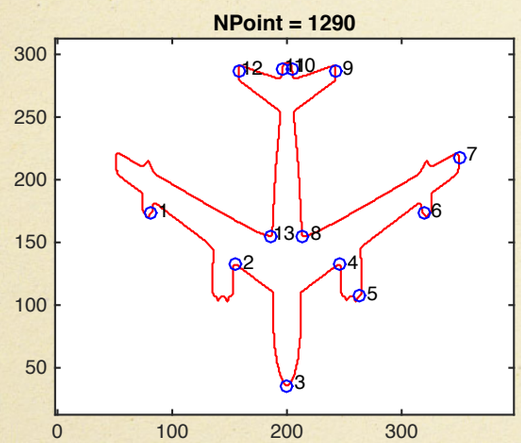


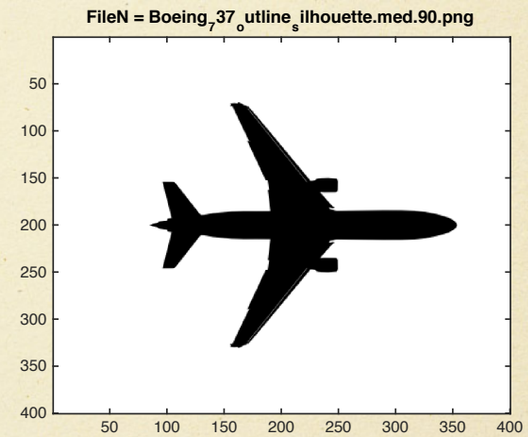
Threshold for using only information points

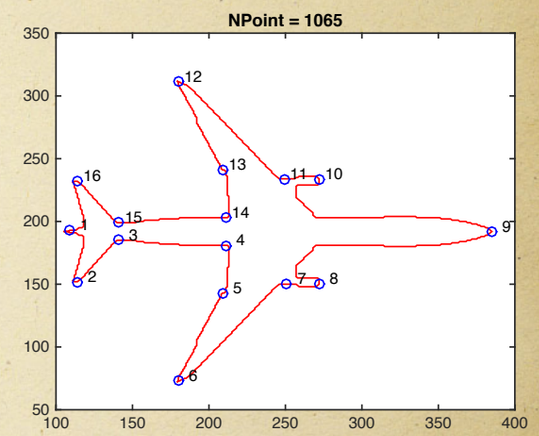
Evolvent of Contour (Contour function)

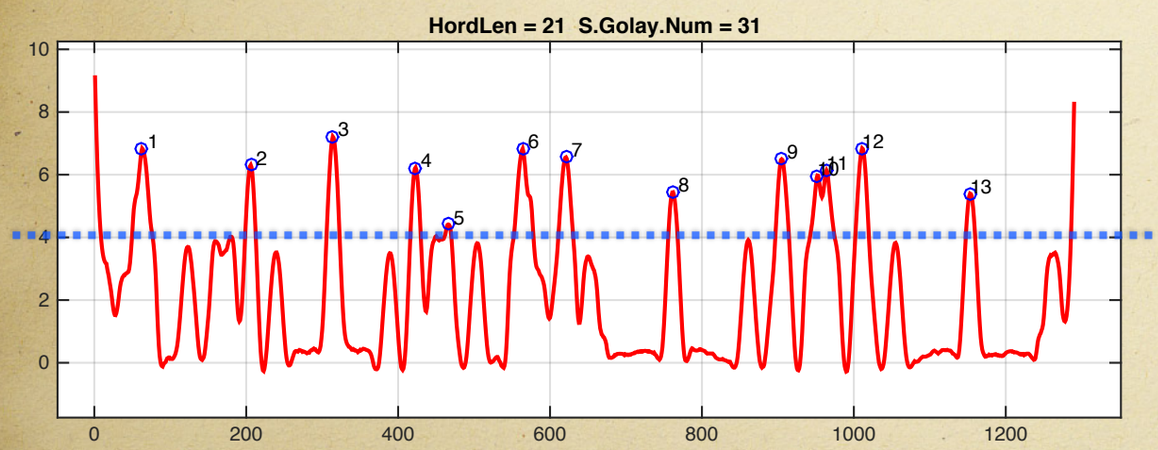
Example (1)

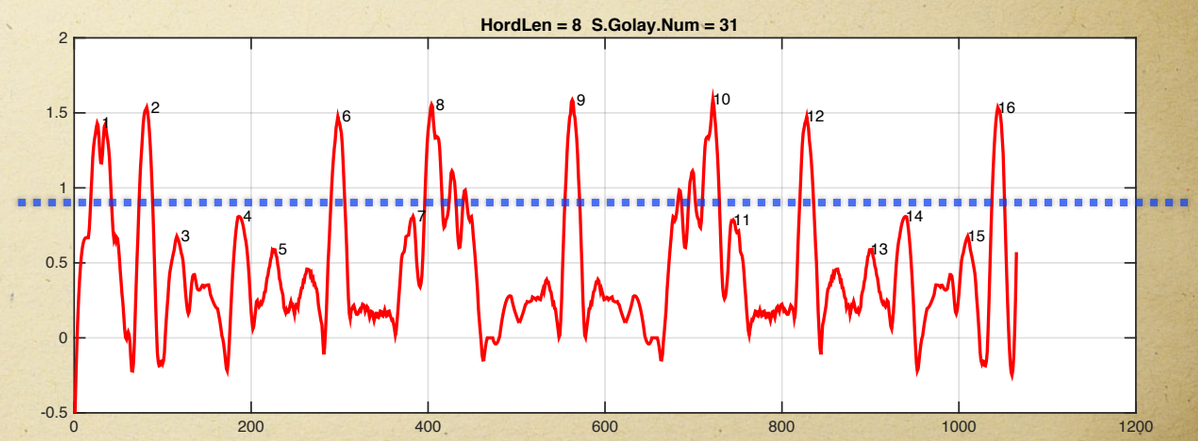

FileN = Boeing_B47E.png


NPoint = 1290

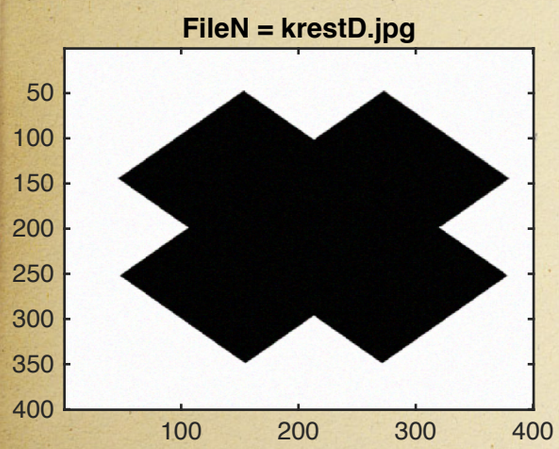

FileN = Boeing_737_outline_silhouette.med.90.png

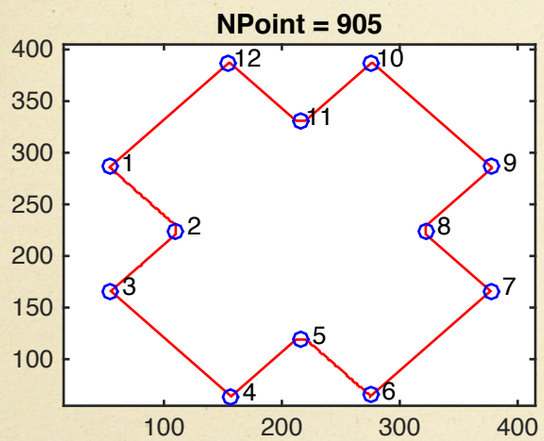

NPoint = 1065

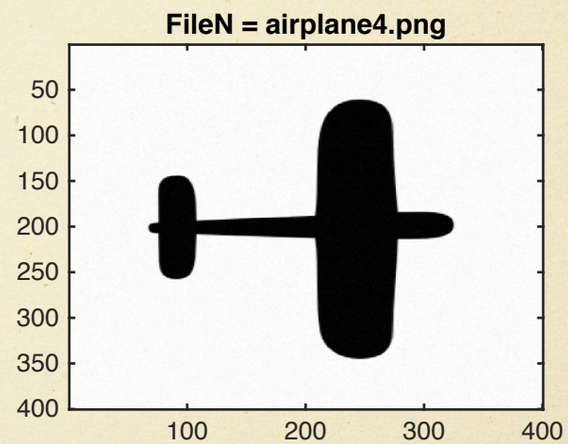

HordLen = 21 S.Golay.Num = 31

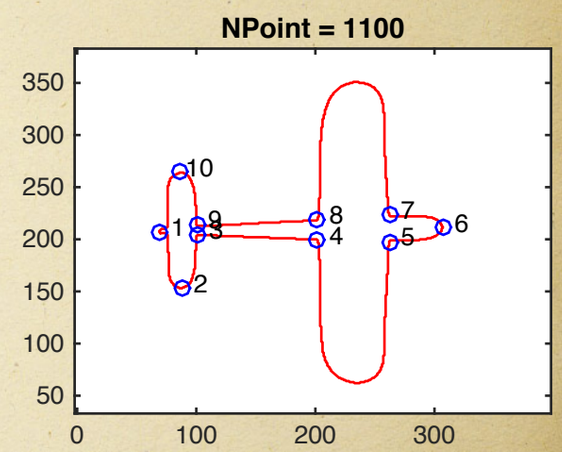

HordLen = 8 S.Golay.Num = 31

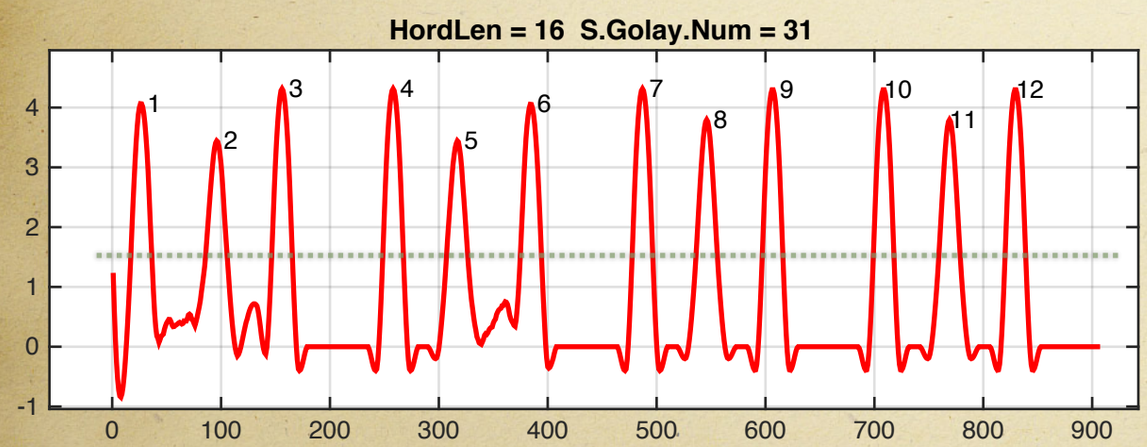
Example (2)

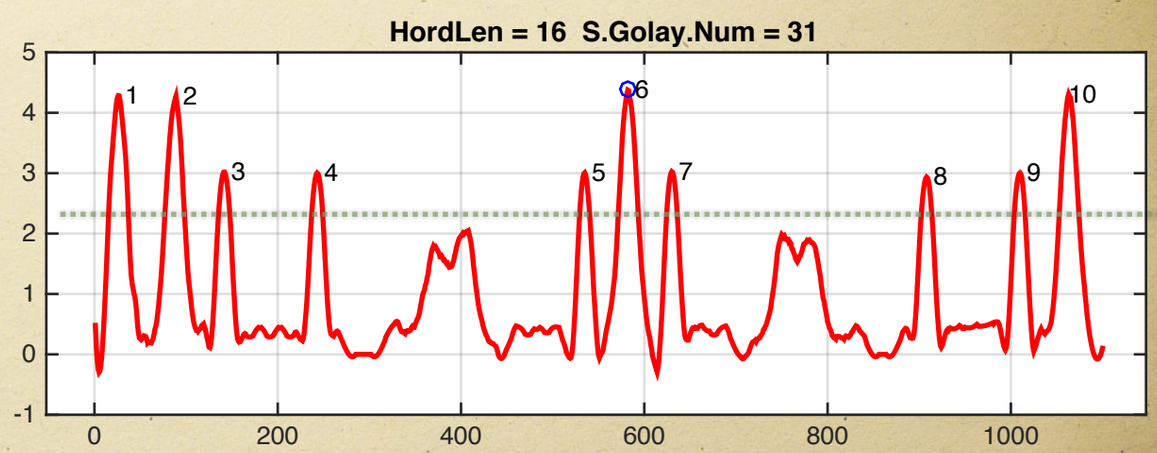












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Definitions

Definition 1. We express set of extrema of function of the sample ***f(t)*** as

$$G_h = \{c = \tau_0 < \tau_1 < \ldots < \tau_m = d\}$$

where t_i -angles of turn of values ***f(t)*** in polar coordinates, and express set of points of identified object as :

$$G_f = \{a = t_0 < t_1 < \ldots < t_l = b\},$$

for function of object ***h(t)***. Amount of the points of the sample is assumed to be greater than the object's one, $l > m$. Otherwise position object and sample should be swapped.

For building metrics of identification adding set of sample *m* points by next manner:

$$G_f^* = \{t_0, t_1, \ldots, t_l, (t_{l+1} = t_l + t_1 - t_0), \ldots, (t_{l+m} = t_l + t_m - t_0)\}.$$

That is adding in tail of set in beginning part of ***m*** points.

$$G_f = \{a = t_0 < t_1 < \ldots < t_l = b\},$$

Definition 2. For some set of points define its mirror set as

$$G^m = \{b = y_0 = t_n > y_1 = t_{n-1} > \ldots > y_n = t_0 = a\}$$

Definitions(2)

Definition 3. Express two-dimensional function of difference between ***f(t)*** and ***h(t)*** as

$$\eta_{i,j} = f(t_{i+j}) - h(\tau_i),\ \ j = \overline{0,(l-m)},\ i = \overline{0,m},\ \tau \in G_h,\ t \in G_f.$$

Definition 4. Express discrete function of ***absolute*** error:

$$\delta_j = \frac{1}{m+1}\sum_{i=0}^{m}\left|\eta_{i,j}\right|, \quad j = \overline{0,(l-m)}$$

And discrete function of ***relative*** error:

$$\sigma_j = \frac{1}{m+1}\sum_{i=0}^{m}\left|\delta_j - \eta_{i,j}\right|, \quad j = \overline{0,(l-m)}$$

Definitions (3)

Definition 5. Introduce recognition function for the identification of curves at incomplete data on the basis of ***correlation on incomplete data*** #1 (CID1) as

$$\lambda_{nk1} = \begin{cases} 1, \ (\rho_{nk1} < \varepsilon_{nk1}) \vee (\rho^{m}_{nk1} < \varepsilon_{nk1}), \\ 0, \ (\rho_{nk1} \geq \varepsilon_{nk1}) \wedge (\rho^{m}_{nk1} \geq \varepsilon_{nk1}) \end{cases}.$$

where $\rho_{nk1} = \min_{j} \delta_j$ means the metrics of correlation on incomplete data #1 and ρ^{m}_{nk1} means the metrics of correlation on incomplete data #1, calculated on a mirror data set, and $\boldsymbol{\varepsilon_{nk1}}$- the classification's tolerance.

Equality $\boldsymbol{\lambda_{nk1} = 1}$ means successful classification object in relation to the sample, thus value $\boldsymbol{j}$ corresponds to a corner of turn of object concerning the sample.

Definitions (4)

Definition 5. express recognition function for identification of curves at incomplete data on the basis of ***correlation on incomplete data*** #2 (CID2) as

$$\lambda_{nk2} = \begin{cases} 1, \ (\rho_{nk2} < \varepsilon_{nk2}) \vee (\rho^{m}_{nk2} < \varepsilon_{nk2}), \\ 0, \ (\rho_{nk2} \geq \varepsilon_{nk2}) \wedge (\rho^{m}_{nk2} \geq \varepsilon_{nk2}) \end{cases}.$$

where $\rho_{nk2} = \min_{j} \sigma_{j}$ means the metrics of correlation on incomplete data #2 and ρ^{m}_{nk2} means the metrics of correlation on incomplete data #2, calculated on a mirror data set, and ε_{nk2}- the classification's tolerance.

Equality $\lambda_{nk2} = 1$ means successful classification object in relation to the sample, thus value j corresponds to a corner of turn of object concerning the sample.

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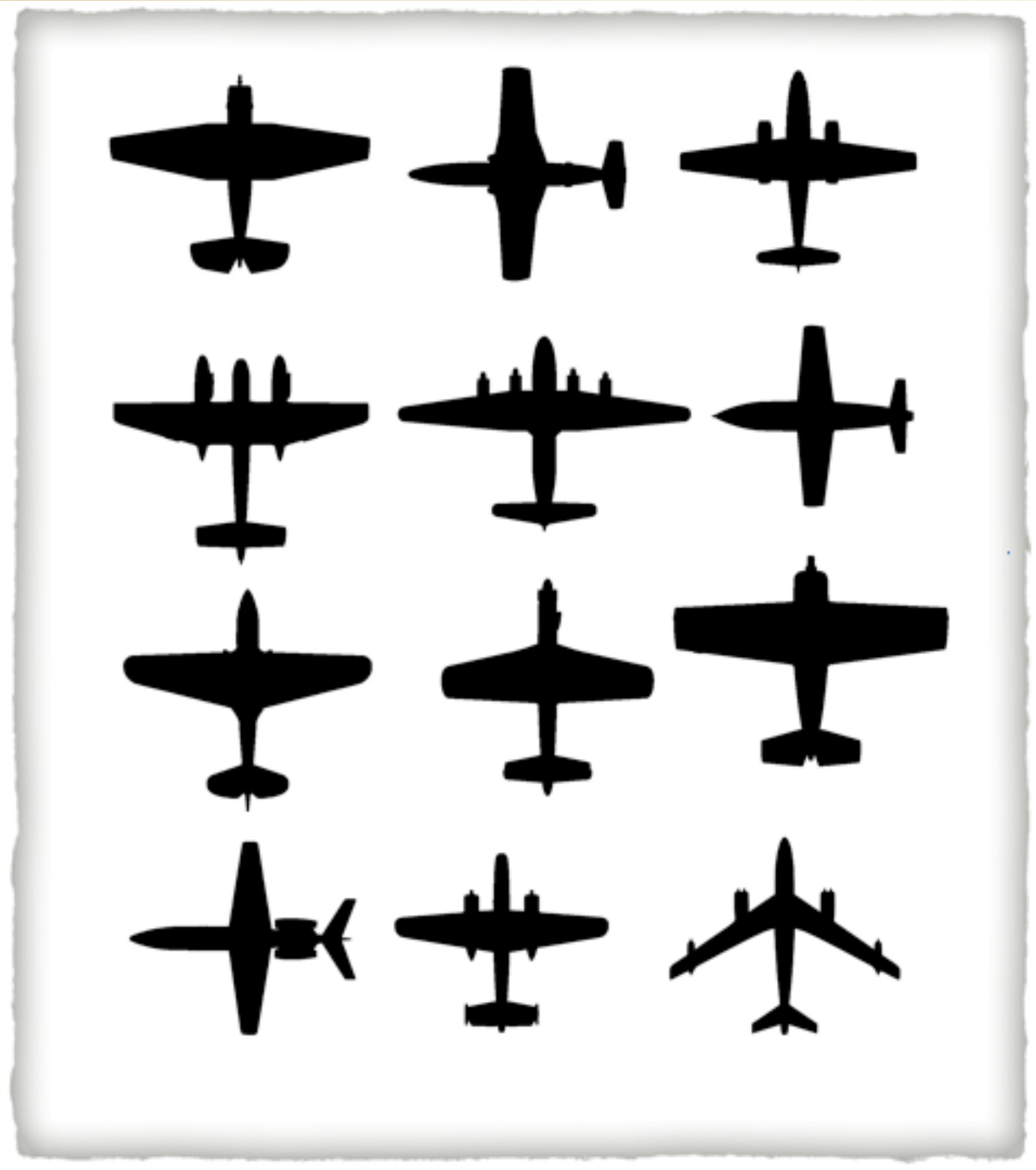
Example of objects for identification



Silhouette of airplane (from top to bottom, from left to write) Grumman TBF-1, Aero L-29, Arado Ar 234B, Arado Ar 240, Avro 668, Bell - X1, Curtiss P-40F, Dornier DO-335A, Grumman F4F-3, Jet Commander 1121, Mitchell - D-25C, Boeing B-47E (Strongly zoomed out).

Results of identification

Table of metric value

sample-sample

	Grumman TBF-1	Aero L-29	Arado Ar 234B	Arado Ar 240	Avro 668	Bell - X1	Curtiss P-40F	Dornier DO-335A	Grumman F4F-3	Jet Commander 1121	Mitchell - D-25C
Grumman TBF-1	2.75E-08	0.1784	0.1778	0.1992	0.1675	0.1675	0.1913	0.1713	0.1058	0.2228	0.1777
Aero L-29	0.1784	1.84E-08	0.1846	0.2279	0.1685	0.1487	0.1357	0.2133	0.1625	0.2671	0.2344
Arado Ar 234B	0.1778	0.1846	2.03E-08	0.2087	0.2016	0.2345	0.2292	0.254	0.2104	0.2	0.2048
Arado Ar 240	0.1992	0.2279	0.2087	7.07E-08	0.1997	0.2427	0.172	0.1904	0.179	0.1639	0.0887
Avro 668	0.1675	0.1685	0.2016	0.1997	4.84E-08	0.244	0.219	0.2361	0.1894	0.2119	0.1785
Bell-X1	0.1675	0.1487	0.2345	0.2427	0.244	8.46E-08	0.1811	0.1821	0.1593	0.2492	0.2541
Curtiss P-40F	0.1913	0.1357	0.2292	0.172	0.219	0.1811	1.48E-07	0.1498	0.1609	0.1908	0.1865
Dornier DO-335A	0.1713	0.2133	0.254	0.1904	0.2361	0.1821	0.1497	3.26E-08	0.158	0.2228	0.209
Grumman F4F-3	0.1058	0.1625	0.2104	0.179	0.1894	0.1593	0.1609	0.158	8.18E-08	0.2228	0.1887
JetCommander 1121	0.2228	0.2671	0.2	0.1639	0.2119	0.2492	0.1908	0.2228	0.2228	1.07E-07	0.2022
Mitchell-D-25C	0.1777	0.2344	0.2048	0.0887	0.1785	0.2541	0.1865	0.209	0.1887	0.2022	8.38E-08

Thank you for attention!

Your Questions?