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72

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MatLab.

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2.

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1) $D_1 -$

2) D_2 – (, ,);

3) D_3 – (, - , .

4) D_4 – , ;

5) D_5 – , () .

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1) R_1 – , ;

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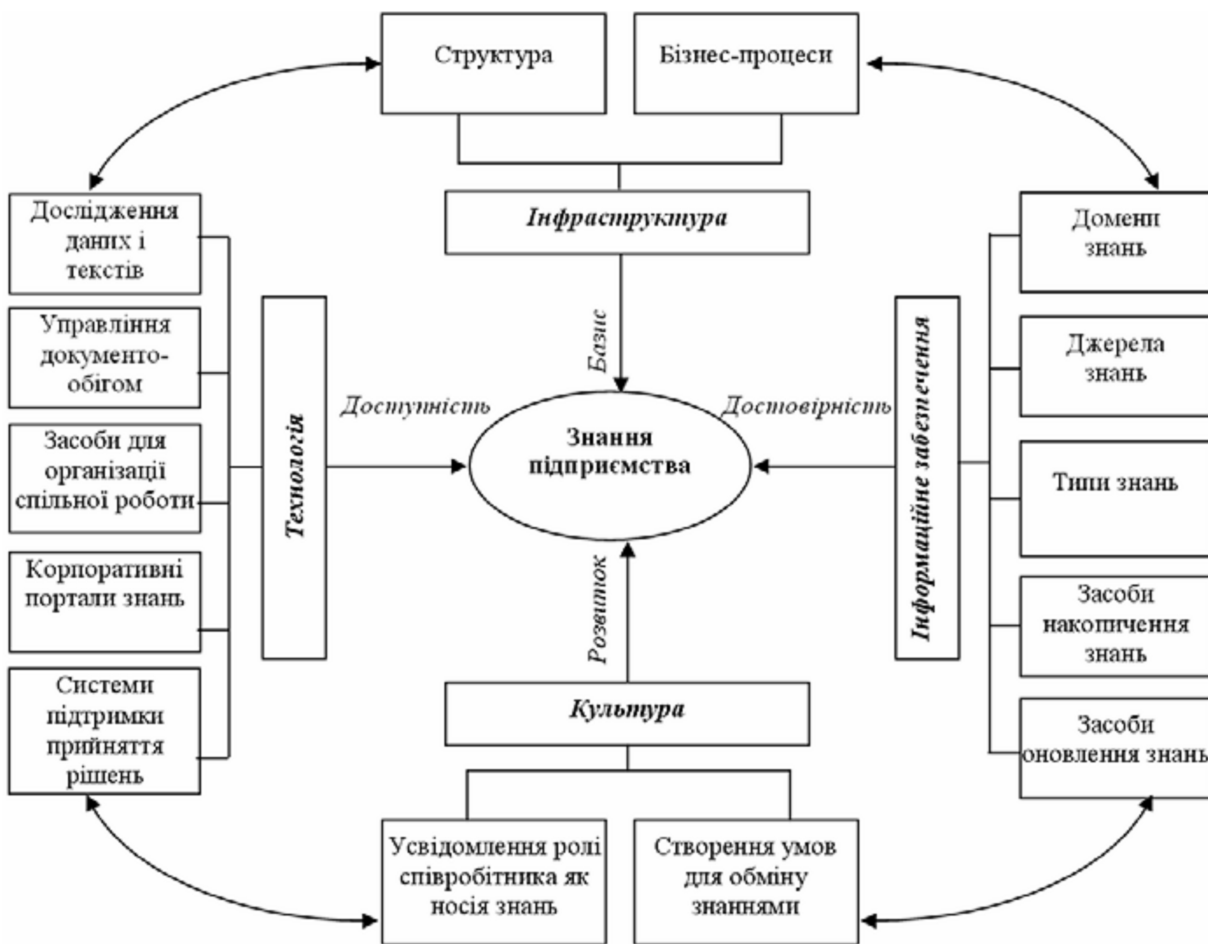
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1.	<p>• • ,</p> <p>• •</p>	<p>,</p> <p>-</p> <p>,</p> <p>-</p> <p>-</p> <p>-</p>	<p>,</p> <p>-</p> <p>,</p> <p>-</p> <p>,</p>
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3.	<p>.</p>	<p>,</p> <p>« - »</p>	<p>,</p> <p>-</p>

4.	<i>American Productivity & Quality Center</i>	,	,
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 3) (Collaboration) -
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 5) (Decision
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$S = \langle B, F, A, R \rangle,$

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F —
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R —

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, $A \subseteq F$;

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« ' » (frame -)

$$f[\langle v_1, g_1 \rangle, \langle v_2, g_2 \rangle, \dots, \langle v_k, g_k \rangle],$$

$$f - ' ;$$

$$\langle v_i, g_i \rangle, i = \overline{1, k}, - i - , v_i - , g_i -$$

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1.

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International Fuzzy Engineering),

LIFE (Laboratory for

19

2.

$$X \subseteq R^1 -$$

(fuzzy set) A

X

$$(x, \mu_A(x)):$$

$$A = \{x, \mu_A(x) \mid x \in X, 0 \leq \mu_A(x) \leq 1\},$$

$\mu_A(x)$ -

x

A .

:

$$A = \{x_1 / \mu_A(x_1), x_2 / \mu_A(x_2), \dots, x_m / \mu_A(x_m)\}.$$

$x \in X$

$[0,1]$.

$$\mu_A(x) = \begin{cases} \max(0, (x_4 - x)/(x_4 - x_3)), & x > x_3 \\ \max(0, (x - x_1)/(x_2 - x_1)), & x < x_2 \\ 1, & x \geq x_2 \text{ and } x \leq x_3 \end{cases}$$

$x_1 < x_2 < x_3 < x_4$.

1

3.

« \tilde{X} », « \tilde{X} »). \tilde{X} (m , « \tilde{X} » ,

$$\tilde{X} = \{A_j \mid j = 1..m\}.$$

X .

$$A_j = \{x, \mu_{A_j}(x) \mid x \in X, 0 \leq \mu_{A_j}(x) \leq 1\}.$$

\tilde{X} :

$$\mu_{A_j}(x), \quad j = 1..m$$

X .

4.

, *NOT*, *AND*, *OR*.
 $\{0,1\}$.

$[0,1]$.

() $\mu \in [0,1]$.

A, B –

4.1. NOT – :
 $NOT A = A' = \{x, \mu_{A'}(x) | x \in X, \mu_{A'}(x) = 1 - \mu_A(x)\}$.
 $NOT(\neg)$ [0,1]:

$$\neg a : [0,1] \rightarrow [1,0].$$

4.2. AND (\cap) – , :
 $A AND B = A \cap B = T_{\cap}(\mu_A(x), \mu_B(x))$.

$$T_{\cap} - , -$$

:

1)

$$T_{\cap}(0,0) = 0, T_{\cap}(\mu,1) = T_{\cap}(1,\mu) = \mu;$$

2)

if $\mu_A \leq \mu_C$ and $\mu_B \leq \mu_D$ then $T_{\cap}(\mu_A, \mu_B) \leq T_{\cap}(\mu_C, \mu_D)$;

3)

$$T_{\cap}(\mu_A, \mu_B) = T_{\cap}(\mu_B, \mu_A);$$

4)

$$T_{\cap}(T_{\cap}(\mu_A, \mu_B), \mu_C) = T_{\cap}(\mu_A, T_{\cap}(\mu_B, \mu_C)).$$

AND (\wedge) –

[0,1]:

$$a \wedge b : [0,1] \times [0,1] \rightarrow [0,1].$$

t-

:

$$A AND B = A \cap B = \min_x(\mu_A(x), \mu_B(x)).$$

4.3. OR (\cup) – , :

$$A OR B = A \cup B = T_{\cup}(\mu_A(x), \mu_B(x)).$$

$$T_{\cap} , T_{\cup} -$$

1)

$$T_{\cup}(1,1) = 1, T_{\cup}(\mu,0) = T_{\cup}(0,\mu) = \mu;$$

2)

if $\mu_A \leq \mu_C$ and $\mu_B \leq \mu_D$ then $T_{\cup}(\mu_A, \mu_B) \leq T_{\cup}(\mu_C, \mu_D)$;

3)

$$T_{\cup}(\mu_A, \mu_B) = T_{\cup}(\mu_B, \mu_A);$$

4)

$$T_{\cup}(T_{\cup}(\mu_A, \mu_B), \mu_C) = T_{\cup}(\mu_A, T_{\cup}(\mu_B, \mu_C)).$$

OR ()

$$a \square b : [0,1] \square [0,1] \square [0,1] \quad [0,1] :$$

$$a \square b : [0,1] \square [0,1] \square [0,1] .$$

t-

:

$$A \text{ OR } B = A \cup B = \max_x (\mu_A(x), \mu_B(x)) .$$

T_{\rightarrow}

:

1)

$$T_{\rightarrow}(\mu, 1) = 1, T_{\rightarrow}(1, \mu) = \mu, T_{\rightarrow}(0, \mu) = 1;$$

2)

$$\text{if } \mu_A \leq \mu_B \text{ then } T_{\rightarrow}(\mu_A, \mu_C) \geq T_{\cup}(\mu_B, \mu_C);$$

3)

$$\text{if } \mu_C \leq \mu_D \text{ then } T_{\rightarrow}(\mu_A, \mu_C) \leq T_{\cup}(\mu_A, \mu_D).$$

:

$$A \rightarrow B = \max_x (1 - \mu_A(x), \mu_B(x)) .$$

(□)

[0,1] :

$$a \rightarrow b : [0,1] \times [0,1] \rightarrow [0,1] .$$

a, b

$$a \rightarrow b = \bar{a} \wedge \bar{b} , a \rightarrow b = \bar{a} \vee b .$$

5.

:

«if -then»

1)

2)

3)

4)

6.

$$\bar{x} = (x_1, x_2, \dots, x_n)$$

$$A' = (A'_1, A'_2, \dots, A'_n)$$

$$A'_i(x, \mu_{A'_i}(x))$$

$$\mu_{A'_i}(x) = \begin{cases} 1, & x = x_i; \\ 0, & x \neq x_i. \end{cases}$$

$A_{i,j}$

$$\mu_{A_{i,j}}(x), \quad j = 1..m_i.$$

$$\mu_{A_{i,j}}(x) = 1, \quad x = x_i,$$

$$A_{i,j}(x_i), \quad i = 1..n.$$

7.

$$\tilde{X} = \{\tilde{X}_i \mid i=1..n\} \quad \tilde{Y} = R(\tilde{X})$$

$$R = \{R_k \mid k=1..N\} \quad R = A \rightarrow B,$$

$$A \rightarrow B \quad B' \quad A'$$

$$B' = A' \bullet R = A' \bullet (A \rightarrow B),$$

• -

if $\quad \quad \quad$ *then* $\quad \quad \quad$,

(is) $\quad \quad \quad \tilde{X}$
 $\{A_{i,j} \mid i=1,..,n; j=1..m_i\}$.

(Mamdani)

(Sugeno).

R_k : if \tilde{X}_1 is $A_{1,k}$ and ... and \tilde{X}_n is $A_{n,k}$ then \tilde{Y} is B_k ,
 $A_{i,k} \in \tilde{X}_i$ - $B_k \in B$ -

k - $(k \in 1..N)$ and

t-

R_k : if x_1 is $A_{1,k}$ and ... and x_n is $A_{1,n}$ then $y = o_k$,
 o_k - k -

1)

;

2)

$R_k, k \in 1..N$

α_k

$A'_i, i = 1..n$

$A_{i,j} (j = 1..m_i)$:

$$\alpha_k = \min_{i=1}^n \left[\max_{X_i} (A'_i \wedge A_{i,j}) \right],$$

$A'_i, i = 1..n;$ \wedge

$$\max_{X_i} (A'_i(x_i) \wedge A_{i,j}) = A_{i,j}(x_i).$$

$$\alpha_k = \min_i (A_{i,j}(x_i)).$$

$$B_k.$$

$$B'_k = \min(\alpha_k, B_k), \quad k = 1..N,$$

$$B'_k$$

$$\alpha_k.$$

$$B' = \max_k (B'_k), \quad k = 1..N.$$

8.

$$y = \frac{\sum_{j=1}^m y_j B'(y_j)}{\sum_{j=1}^m B'(y_j)} .$$

$$\mu_{o_k}(y_k) = \begin{cases} 1, & y_k = o_k \\ 0, & y_k \neq o_k \end{cases} ,$$

o_k —

k -

$$y = \frac{\sum_{k=1}^N \alpha_k y_k}{\sum_{k=1}^N \alpha_k} .$$

9.

()

- = (,);
- = (,);
- = (, ,).

R_1 : ,
;
 R_2 : ,
;
 R_3 : ,
.

:
= {100/0.2; 200/0.4; 300/0.8; 400/1};
= {100/1; 200/0.8; 300/0.6; 400/0.4};
= {50/0.1; 71/0.8; 88/0.9; 100/1};
= {50/1; 71/0.3; 88/0.2; 100/0.1}.
:
= {0/0.1; 0.5/0.5; 1/1};
= {0/0.5; 0.5/1; 1/0.5}.

$$A'_1 = \{100/0.4; 200/0.3; 300/0.2; 400/0.1\}$$

$$A'_2 = \{50/0.1; 71/0.8; 88/0.8; 100/0.1\}.$$

∧ ∨

:

1.

$$\alpha_1 = \min[\max(0.4^{0.2}, 0.3^{0.4}, 0.2^{0.8}, 0.1^1), \max(0.1^{0.1}, 0.8^{0.8}, 0.8^{0.9}, 0.1^1)] = \min[\max(0.2, 0.3, 0.2, 0.1), \max(0.1, 0.8, 0.8, 0.1)] = \min[0.3, 0.8] = 0.3$$

$$\alpha_2 = \min[\max(0.4^1, 0.3^{0.8}, 0.2^{0.6}, 0.1^{0.4}), \max(0.1^{0.1}, 0.8^{0.8}, 0.8^{0.9}, 0.1^1)] = \min[\max(0.4, 0.3, 0.2, 0.1), \max(0.1, 0.8, 0.8, 0.1)] = \min[0.4, 0.8] = 0.4$$

$$\alpha_3 = \min[\max(0.4^{0.2}, 0.3^{0.4}, 0.2^{0.8}, 0.1^1), \max(0.1^1, 0.8^{0.3}, 0.8^{0.2}, 0.1^{0.1})] = \min[\max(0.2, 0.3, 0.2, 0.1), \max(0.1, 0.3, 0.2, 0.1)] = \min[0.3, 0.3] = 0.3$$

2.

$$B'_1 = \{0/\min(0.3, 0.1), 0.5/\min(0.3, 0.5), 1/\min(0.3, 1)\} = \{0/0.1, 0.5/0.3, 1/0.3\}$$

$$B'_2 = \{0/\min(0.4, 0.5), 0.5/\min(0.4, 1), 1/\min(0.4, 0.5)\} = \{0/0.4, 0.5/0.4, 1/0.4\}$$

$$B'_3 = \{0/\min(0.3, 0.5), 0.5/\min(0.3, 1), 1/\min(0.3, 0.5)\} = \{0/0.3, 0.5/0.3, 1/0.3\}$$

3.

$$B' = B'_1 \vee B'_2 \vee B'_3 = \{0/\max(0.1, 0.4, 0.3), 0.5/\max(0.3, 0.4, 0.3), 1/\max(0.3, 0.4, 0.3)\} = \{0/0.4, 0.5/0.4, 1/0.4\}$$

4.

$$y = \frac{0 * 0.4 + 0.5 * 0.4 + 1 * 0.4}{0.4 + 0.4 + 0.4} = \frac{0.6}{1.2} = 0.50$$

50 %.

10.

Matlab

Fuzzy logic toolbox –

Matlab

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Matlab;

•

Matlab)

SimuLink (

;

• Matlab -
 , , . -
 :
 • (command line functions);
 • ;
 • SimuLink.
 - , -
 Matlab. -
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 , Matlab *type* ' - . -
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 - SimuLink.
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 Matlab , -
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 • Z- ;
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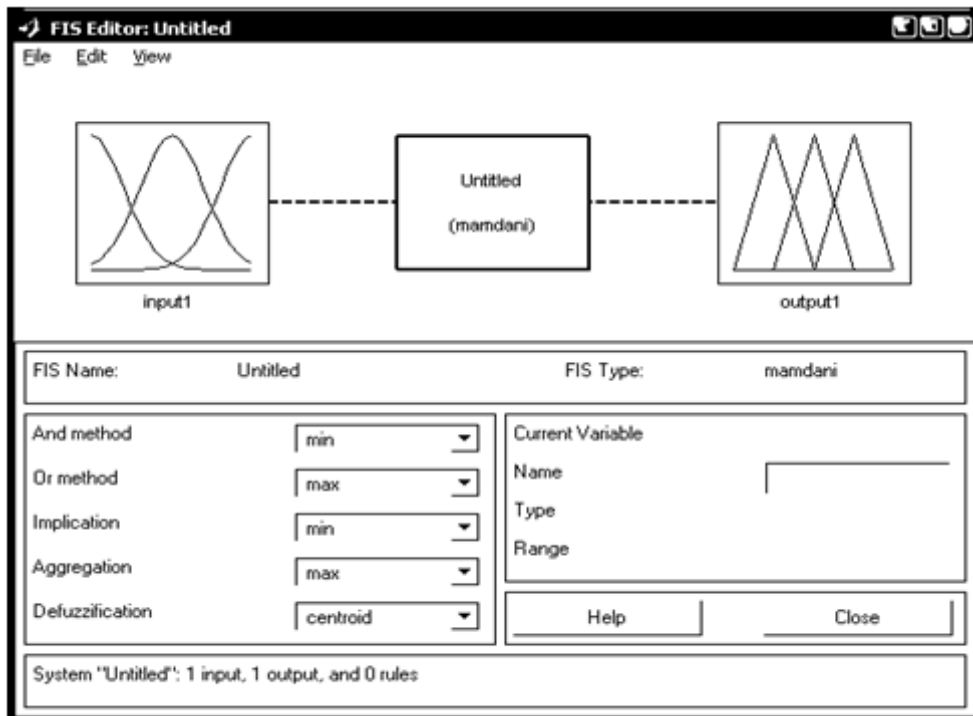
MatLab.

From disk

.fis .

Ctrl+N

fuzzy FIS_name, FIS_name –



. 3.1. FIS-

Export

To

Workspace... To disk,

MatLab

To Workspace...

MatLab.

To disk

Ctrl+T Ctrl+S .

Print -

. Ctrl+P.

Close .

Ctrl+W -

Close.

Edit: **Undo** .

Ctrl+Z. **Add**

Variable... -

.

Input Output, -

. **Remove Selected Variable** -

. -

. -

Ctrl+X. -

Membership Function... -

. -

Ctrl+2. -

Rules... -

Ctrl+3. -

View - GUI- , -

.

(**Rules** Ctrl+5)

« - »,

(**Surface**

Ctrl+6). -

And Method -

" ": min - ; prod - .

" " . -

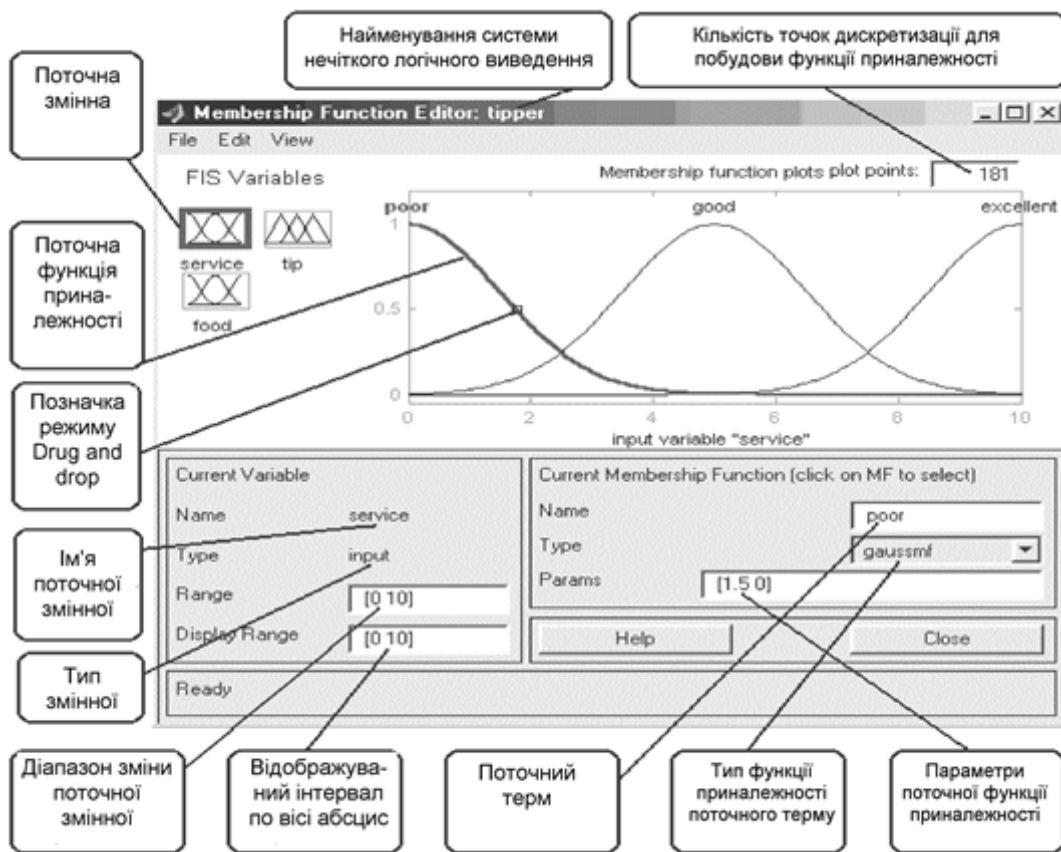
Custom... , ' , , -

, .

Or Method –
 " " : max – ; probor –
 " ".
 " ".
Custom... , ' , ,
 , .
Implication –
 : min – ; prod – .
 .
Custom... , ' , ,
 , .
Aggregation –
 ,
 : max – ; sum – ; probor – " ".
 .
Custom... , ' , , ,
 , .
Defuzzification –
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 : centroid – ; bisector – ; lom –
 ; som – ; mom –
 .
 : wtaver – ; wtsum – .
 .
Custom...
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 .
 (Membership Function
 Editor)
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- GUI- , Membership Functions...
 Edit Ctrl+2.
 FIS-

. 3.2.



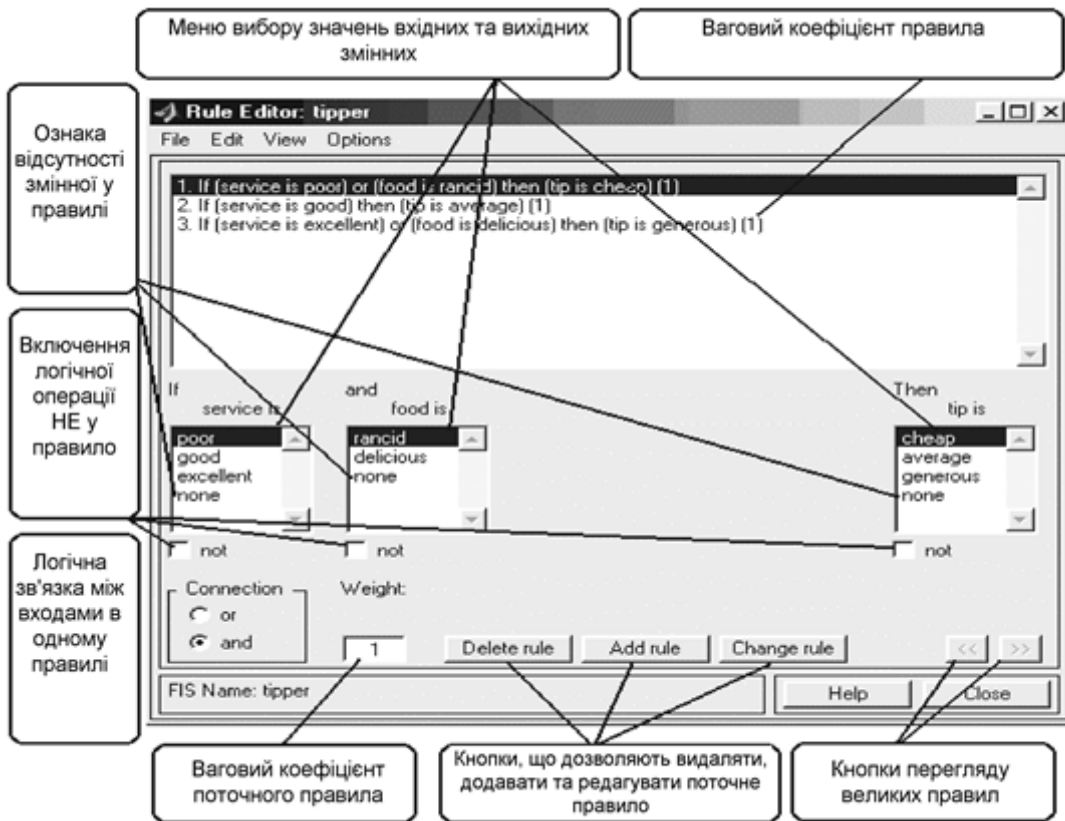
. 3.2.

File, Edit, View, Type
Range, Display Range, Name Params.

			-
	«Drug and drop».		-
		«Drug and drop»,	-
	,	,	
	.		
	.		
Edit:	Undo		.
		Ctrl+Z.	
	Add MFs...		-
,			-
.			.
	,		-
		Range.	-
	Range		
	.		
	Add Custom MF...		-
,			-
.			.
		(MF	
name),		(M-File function name)	
		(Parameter list).	
	Remove Selected MF		-
-			-
			.
	Remove All MFs		-
	.		
	FIS Properties...	FIS-	-
		Ctrl+1.	
	Rules...		.
		Ctrl+3.	

Type

,
 .
 (Rule Editor) -
 - GUI- ,
 , Rules... -
Edit Ctrl+3. FIS- -
 , . -
 . 3.3. -
Help Close, -
 . -
File, Edit, View, Options, -
 , , -
 , . -
 , -
 () , -
 , -
 , -
Add Rule. -
 : , -
 - ; -
 - 1. -
 , -
 , -
 . -
 none.



. 3.3.

Delete Rule.

Edit Rule.

MatLab

Edit:

Undo

Ctrl+Z.

FIS Properties...

FIS-

Ctrl+1.

Membership Function...

Ctrl+2.

Options

Language

English (), Deutsch (), Francais (),

Format ,
: Verbose – ; **Symbolic** –
;Indexed –

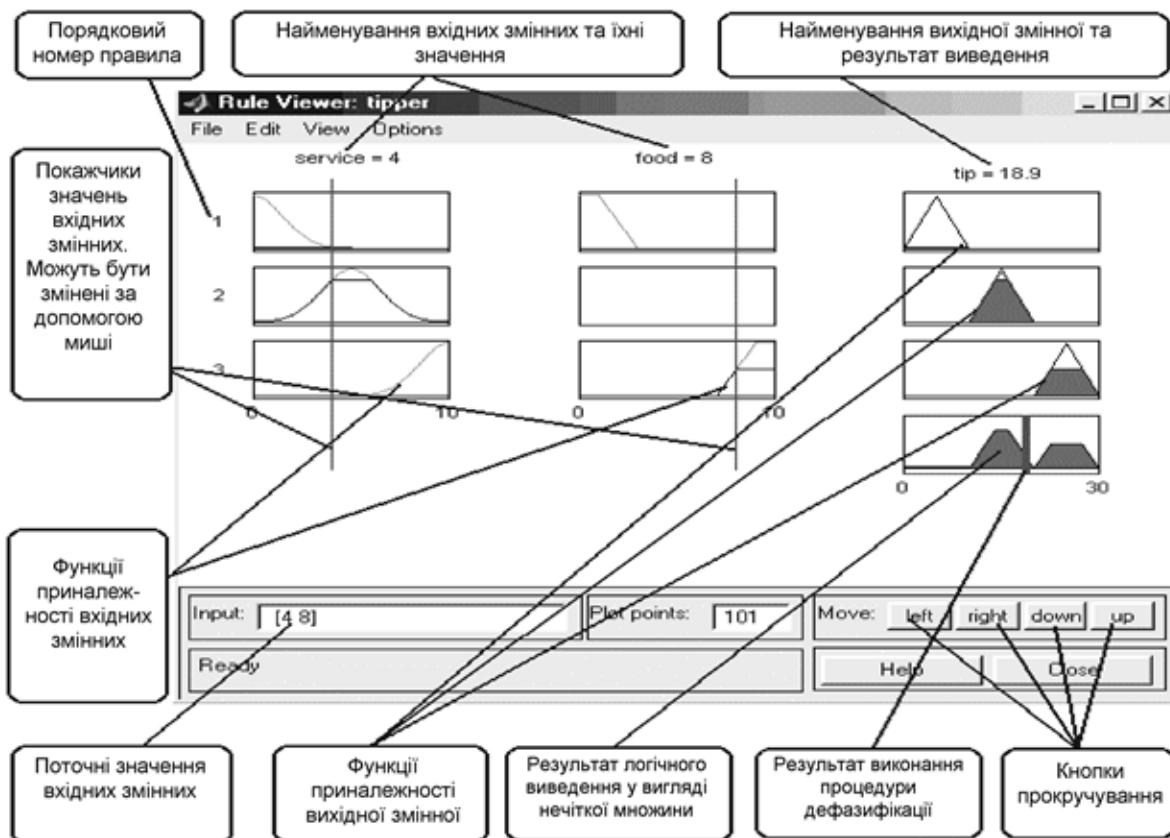
GUI- Rule Viewer.

. Rule Viewer

GUI-

,
View rules ... View
 Ctrl+4. **Rule Viewer**
tipper

. 3.4.



. 3.4. Rule Viewer

Rule Viewer

– File, Edit, View, Options,

– Input Plot points (left-right), (up-down).

Help Close,

.
(
,
- (-).
, food (food is
none).

Editor

Rule

Input;

Input.

Plot points

- 101.

tipper

Edit:

FIS Properties...

FIS-

Ctrl+1.

Membership Functions...

Ctrl+2.

Rules...

Ctrl+3.

Options

Format,

: **Verbose** -

; **Symbolic** -

; **Indexed** -

1. « »?

2.

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3. « »?

4. « » « - »?

5. ?

6. ?

7.

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8.

MatLab?

9.

MatLab?

10.

?

3.1

$\langle \beta, T, X, G, M \rangle,$

β — , ;

T — — , ;

X — — ;

G — — ;

$\langle X, \mu_i(X) \rangle, \mu_i(X)$ —

MATLAB

fuzzy **<Enter>**.

(),

1.

< > < > []

2. $\mu(y) = \min\{c_1, \dots, c_q\}$

3. $\mu(y) = \min\{c_1, \dots, c_q, \mu(y)\}$

3.1. $\mu(y) = \min\{c_1, \dots, c_q, \mu(y)\}$

3.2. $\mu(y) = \min\{c_1, \dots, c_q, \mu(y)\}$

3.3. $\mu(y) = \min\{c_1, \dots, c_q, \mu(y)\}$

4. $\mu(y) = \min\{c_1, \dots, c_q, \mu(y)\}$

$c_k = b_k F_k$

$F_k = \mu(y)$

$C = (c_1, \dots, c_q)$

$\mu(y) = \min\{c_1, \dots, c_q, \mu(y)\}$

$\mu(y) = \min\{c_1, \dots, c_q, \mu(y)\}$

$\mu(y) = \min\{c_1, \dots, c_q, \mu(y)\}$

$\mu(y) = \min\{c_1, \dots, c_q, \mu(y)\}$

$\mu(y) = \min\{c_1, \dots, c_q, \mu(y)\}$

$\mu(y) = \min\{c_1, \dots, c_q, \mu(y)\}$

$\mu(y) = \min\{c_1, \dots, c_q, \mu(y)\}$

- prod- : $\mu'(y) = c_i \mu(y)$;
- average- : $\mu'(y) = 0.5(c_i + \mu(y))$.

5.

$\mu_1(y), \dots, \mu_p$,

- : $\mu'(y) = \max\{\mu_1(y), \mu_2(y)\}$;
- : $\mu'(y) = \mu_1(y) + \mu_2(y) - \mu_1(y)\mu_2(y)$;
- : $\mu'(y) = \max\{\mu_1(y) + \mu_2(y) - 1, 0\}$;
- λ - : $\mu'(y) = \lambda\mu_1(y) + (1-\lambda)\mu_2(y)$, $\lambda \in [0,1]$.

- :
$$\mu'(y) = \begin{cases} \mu_1(y), & \text{if } \mu_2(y) = 0, \\ \mu_2(y), & \text{if } \mu_1(y) = 0, \\ 1, & \text{else.} \end{cases}$$

6.

$$z = \frac{\int_{y_{\min}}^{y_{\max}} y \mu'(y) dy}{\int_{y_{\min}}^{y_{\max}} \mu'(y) dy}, \quad z = \frac{\sum_{i=1}^n y_i \mu'(y_i)}{\sum_{i=1}^n \mu'(y_i)}$$

1.

$$y = (x_1^2 - 8)\cos(x_2)$$

$$x_1 \in [0,4]; x_2 \in [0,4].$$

```
% y=(x1^2-8)*cos(x2)
% x1 [0,4] x2 [0,4].
n=15;
x1=0:4/(n-1):4;
x2=0:4/(n-1):4;
y=zeros(n,n);
for j=1:n
y(j,:)=(x1.^2-8)*cos(x2(j));
end
surf(x1,x2,y)
xlabel('x1')
ylabel('x2')
zlabel('y')
title('Target').
```

. 3.1.1.

1.

fis-

(

fuzzy.

2.

Add Input

Edit.

3.

Input1,

1
<Enter>.

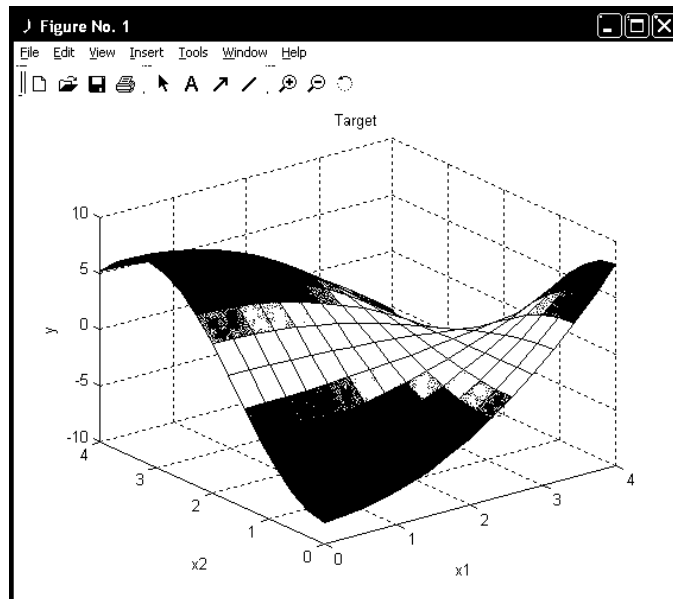
4. input2,
x2

<Enter>.
5.

output1,

y
<Enter>.

6. File
Export to disk , first.



. 3.1.1.

7.

x1.

8.

x1.

0 4

Range

<Enter>.

9.

x1.

3

Edit

Add MFs...

3
 <Enter>.
 10. x1.
 (. 3.2).
 , L (), Name
 <Enter>.
 , A (), Name <Enter>.
 , H (), Name <Enter>.
 . 3.1.2.
 11. x2.
 5
 x2
 x2. 0 4
 Range (. 3.3) <Enter> Edit
 Add MFs... MF type 5
 gaussmf <Enter>.
 Number of MFs.
 12. 10
 x2: L (), LA (), A
 (), HA (), H ().
 . 3.1.3.
 13. y.
 5
 y
 y. - 10 10
 Range (. 3.4) <Enter> Edit
 Add MFs...
 5 Number of MFs.
 <Enter>.

14. $y: L (\quad), LA (\quad) A$
 $(\quad), HA (\quad), H (\quad).$

. 3.1.4.

15.

RuleEditor.

Edit

Rules

View

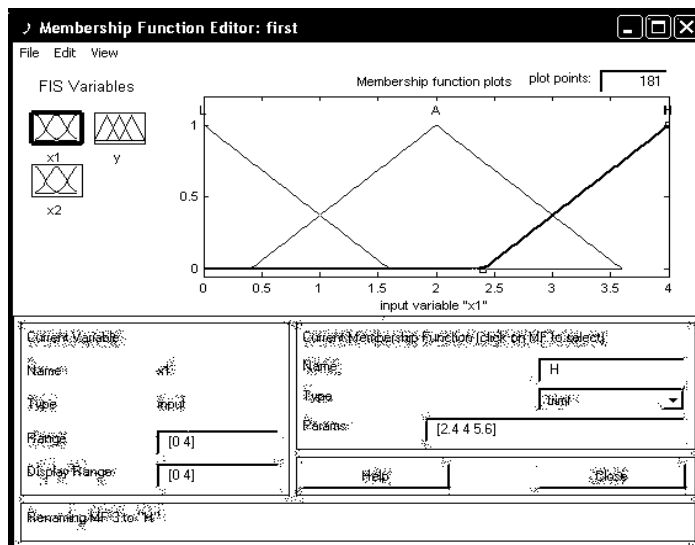
Edit rules....

16.

. 1.1,

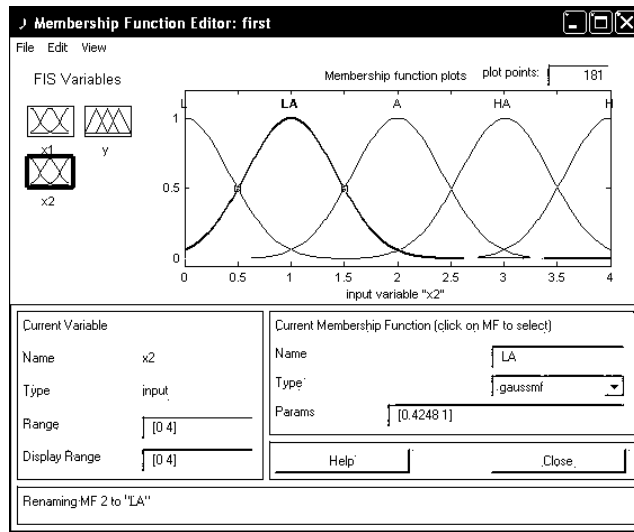
:

1. $x1 = \quad x2 = \quad , y = \quad .$
2. $x1 = \quad x2 = \quad , y = \quad .$
3. $x1 = \quad x2 = \quad , y = \quad -$
- . .
4. $x1 = \quad x2 = \quad , y = \quad -$
- . .
5. $x1 = \quad x2 = \quad , y = \quad .$
6. $x1 = \quad x2 = \quad , y = \quad .$
7. $x1 = \quad x2 = \quad , y = \quad -$
- . .
8. $x1 = \quad x2 = \quad , y = \quad -$
- . .
9. $x1 = \quad x2 = \quad , y = \quad -$
- . .



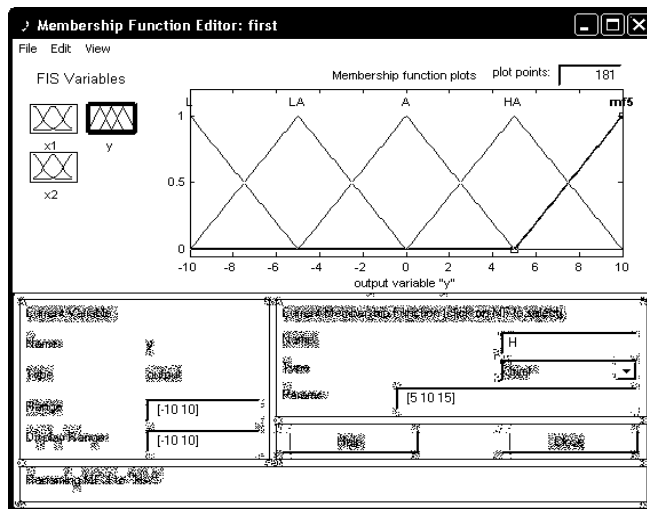
. 3.1.2.

x_1

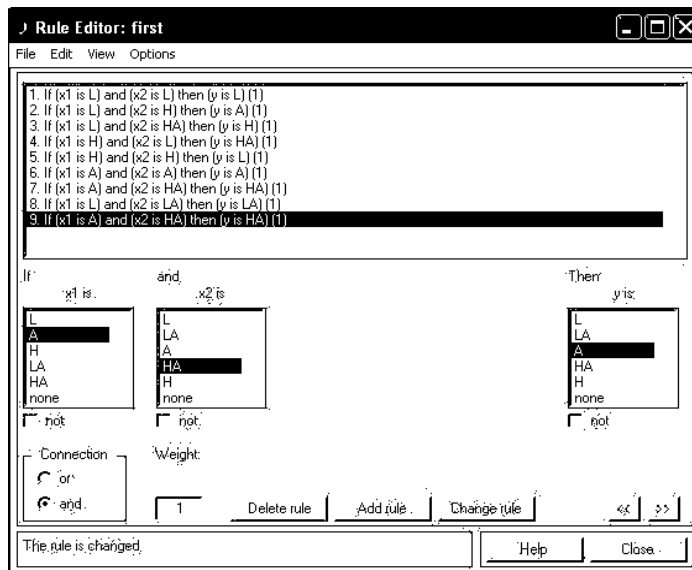


. 3.1.3.

x_2



. 3.1.4.



. 3.1.5.

Add rule.

. 3.1.5
9

Weight,

[0, 1].

17.

File

Export

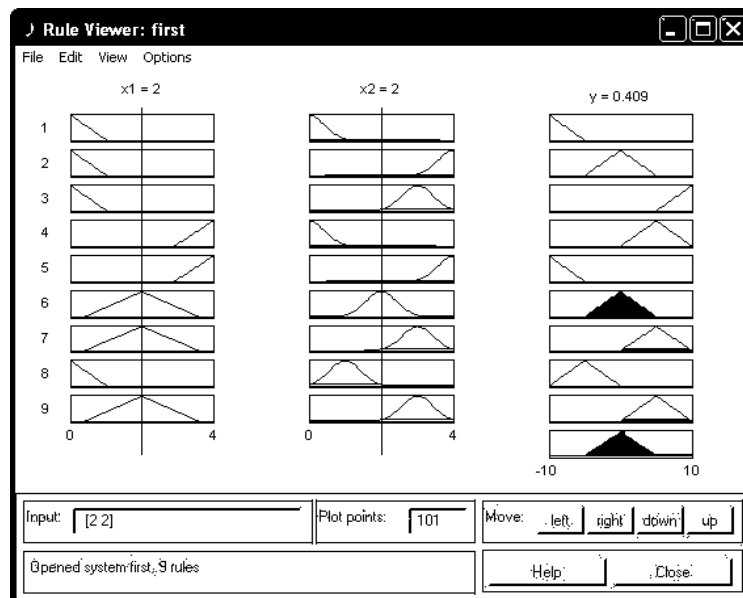
To disk.

. 3.1.6

View rules...

View.

Input



. 3.1.6.

. 3.1.7

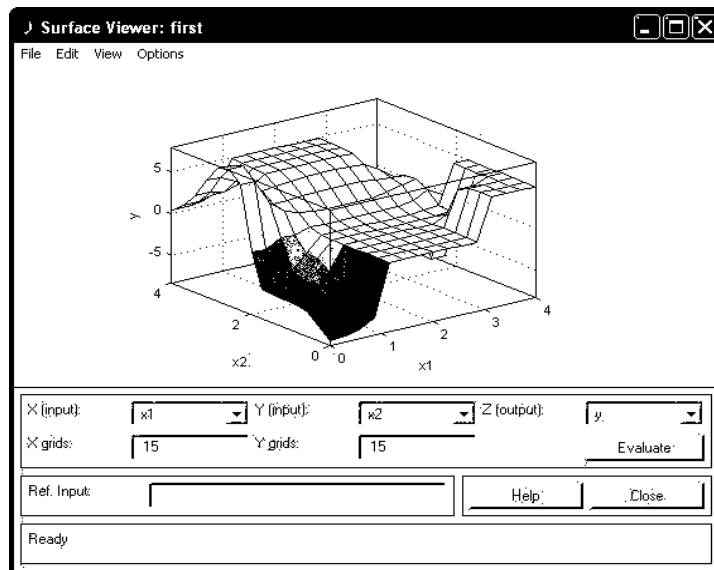
« - »,

View surface...

View.

. 3.1.1

. 3.1.7,



. 3.1.7.

« - »

1.

$$y = x_1^2 \sin(x_2 - 1) \quad , \quad x_1 \in [-7, 3]; x_2 \in [-4.5, 2].$$

2.

$$y = \ln(x_1 + 1) \cos(x_2) \quad , \quad x_1 \in [1, 5]; x_2 \in [0, 2].$$

3.

$$y = \ln(x_1 + 1) \frac{1}{1 + x_2} \quad , \quad x_1 \in [1, 5]; x_2 \in [0, 2].$$

3.2

.

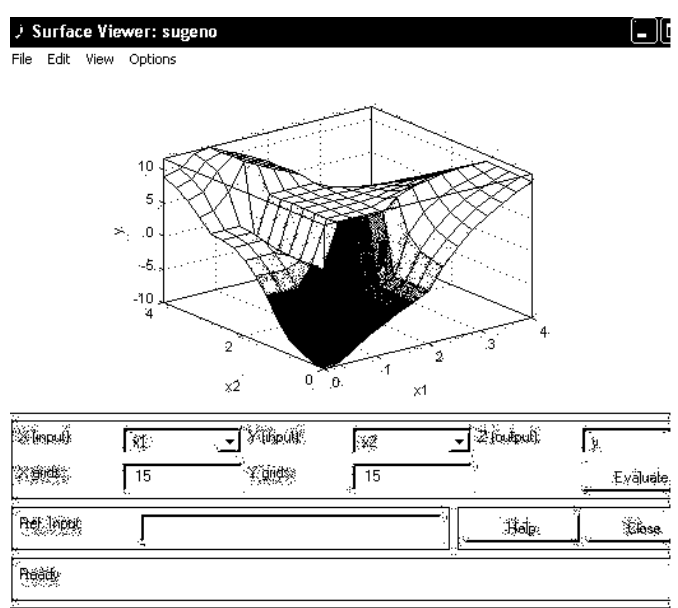
:

(3.2.1),
 $x_1 \in [0,4]; x_2 \in [0,4]$.

$$y = (x_1^2 - 8) \cos x_2$$

<#>: « $x_1 =$ » « $x_2 =$ »
 « $y = k_1 A + k_2 B + k_0$ »

<#>: « $x_1 =$ » « $x_2 =$ »
 « $y =$ ».



. 3.2.1.

1. $x_1 = 1, x_2 = 2, y = -10.$
2. $x_1 = 1, x_2 = 2, y = 3,75x_2 - 10.$
3. $x_1 = 1, x_2 = 2, y = 7.$
4. $x_1 = 1, x_2 = 2, y = -10.$
5. $x_1 = 2, x_2 = 2, y = 4x_1 - 10.$
6. $x_1 = 1, x_2 = 2, y = 15 - 3,75x_2.$
7. $x_1 = 2, x_2 = 2, y = 15 - 3,75x_1.$
8. $x_1 = 1, x_2 = 2, y = 7.$

9. 1 2 , $y = 7$.

10. -

1. fis- -

fuzzy Mathlab.

2. File -

New fis... Sugeno. Edit

3. Add input.

4. input1, -

x1

<Enter>. -

5. input2, -

x2

<Enter>. -

6. output1, -

y

<Enter>. -

7. File -

Export To disk , -

, FirstSugeno.

8. -

x1.

9. x1. -

0 4 Range <Enter> (. 3.2.2).

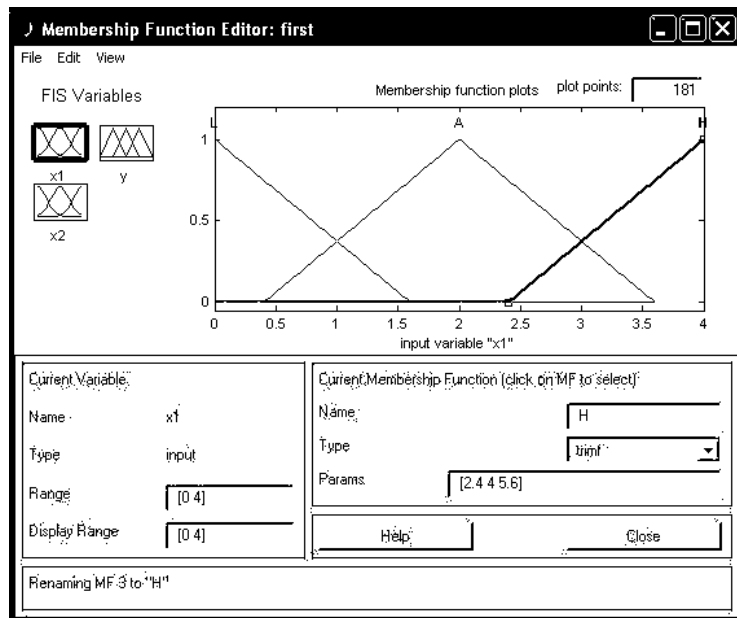
10. x_1 . -

3

x_1 . -

11.

x_2 .
 4
 x_2
 x_2 .
 x_2 .
0 4 Range **<Enter>**.
 (, L , A , HA
 , H).



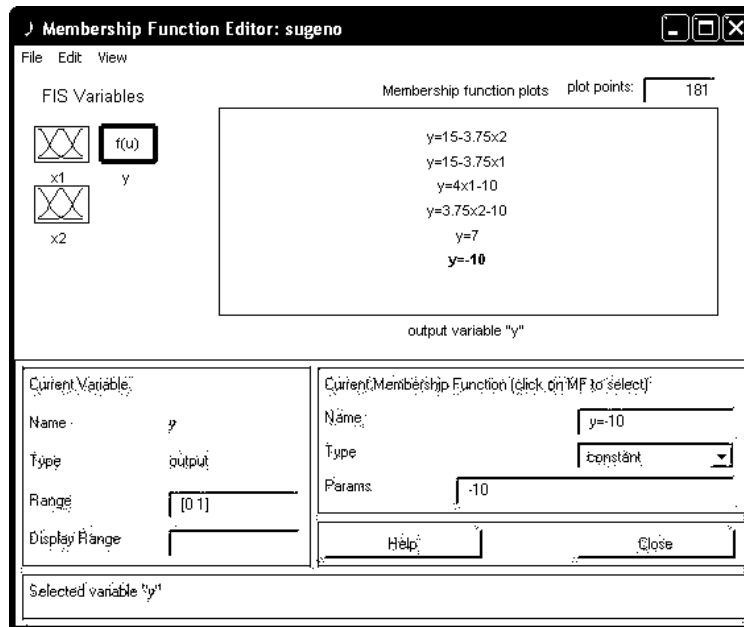
. 3.2.2. x_1

12.

(. 3.2.3).
 y , y .
 ,
 ,
 6 : $y = -10$; $y = 7$; $y = 3,75 x_1 - 10$; $y = 4 x_1 - 10$;
 $y = -3,75 x_1 + 15$; $y = -3,75 x_2 + 15$.

Add Mfs...

Edit.



. 3.2.3.

<< - >>

13.

-

mf1.
Name,
y = -10,

,

-

constant **Type.**
- -10 **Params.**
y = 7.

-

mf3

,

,

y = 3.75 x1-10.

Linear **Type**

3.75 0 -10 **Params.**

-

:

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— ” —

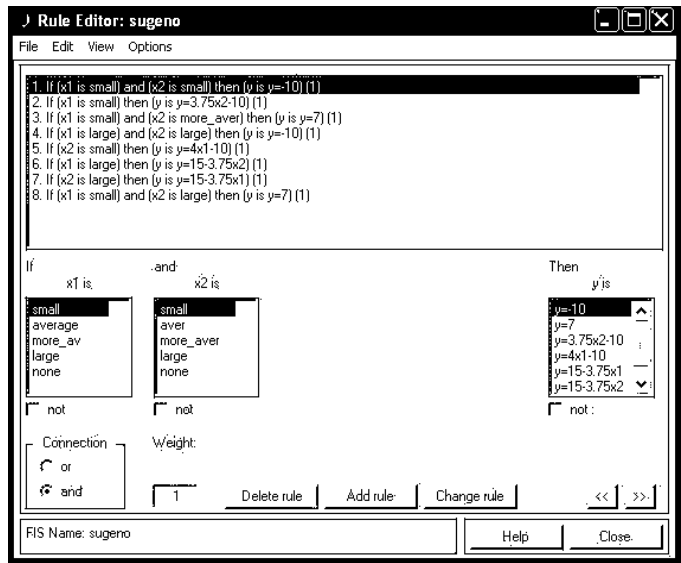
-

6

y.

. 3.2.4.

,



. 3.2.4.

14.

RuleEditor.

Edit

Edit rules...

Add rule.

. 3.2.3

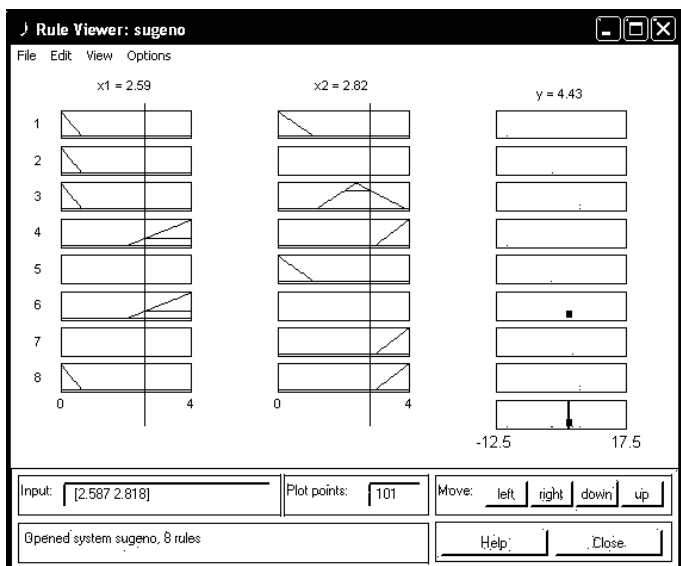
6

. 3.2.5

View rules...

View.

Input



. 3.2.5.

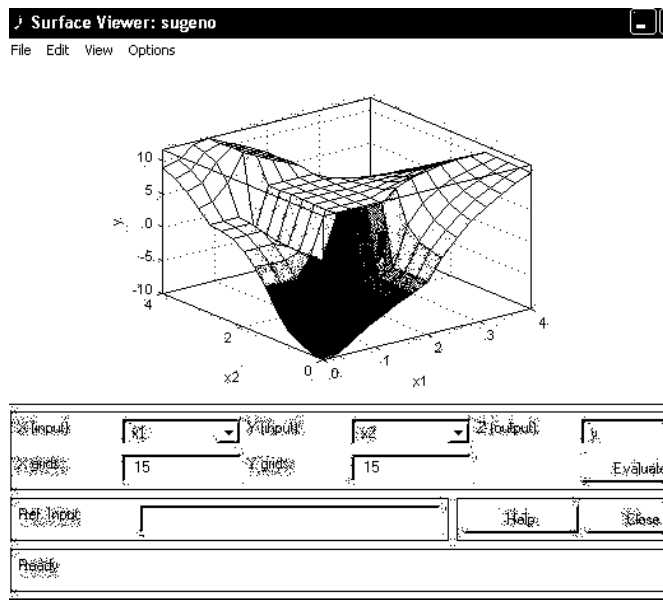
. 3.2.6

« - »,

View surface...

View.

. 3.2.1,



. 3.2.6.

« - »

1.

$$y = x_1^2 \sin(x_2 - 1) \quad x_1 \in [-7,3]; x_2 \in [-4.5,2].$$

2.

$$y = \ln(x_1 + 1) \cos(x_2) \quad x_1 \in [1,5]; x_2 \in [0,2].$$

3.

$$y = \ln(x_1 + 1) \frac{1}{1 + x_2} \quad x_1 \in [1,5]; x_2 \in [0,2].$$

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« »

(, NPV),

:

$$NPV = \sum_{t=0}^T \frac{P(t) - IV(t)}{(1+q)^t},$$

$P(t)$ –

$t \in [0, T]$, $IV(t)$ –

, q – ()

1.

«

»

2.

100 %.

3.

$$\frac{NPV}{NPV_{\max}}$$

4. , ,
5. . ,
, ,
6. , ,
- 1,5 7. . ,
1,5 ,
8. . , ,
9. , . ,
10. . ,
, ,
11. , , . ,
12. , , . ,
13. , . ,
14. , . ,
1,5 ,
15. , . ,
, ,

16. , -
 , -
 . , « » -
 0 %.

17. , ,
 ,
 1,5 .

18. , ,
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19. , ,
 , -
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0,75.

20. , , -
 , 0 %.

3.

(Risk) - « »
 1 = {« », « », « »}
 {RD, RM, RS, RV}. 1 =

" -
 " (Social-meaning) -
 2 = {« », « », « », « »}
 2 = {SN, SNS, SS, SV}.

(NPV) - « »
 3 = {« », « », « »}
 3 = { N, CS, CV}.

- « -
 »" (redit) -
 T6 = {«0», « 5 », « 3 -
 », « 1,5 », « », «1»} -
 T6 = {P_0, P5, P3, 1_5, 1, P_1}.

4.

20

3.3.1.

3.3.1

-				
1.	RD	SV	CV	P1
2.	RD	SS		P_1
3.	RM	SNS		P3
...				

1-40

(« »),

min-

m -

L .

FIS 3 « » (Risk), « » (Social), « » (NPV) « » (Credit).

FIS

. 3.3.2.

L .

3-

L .

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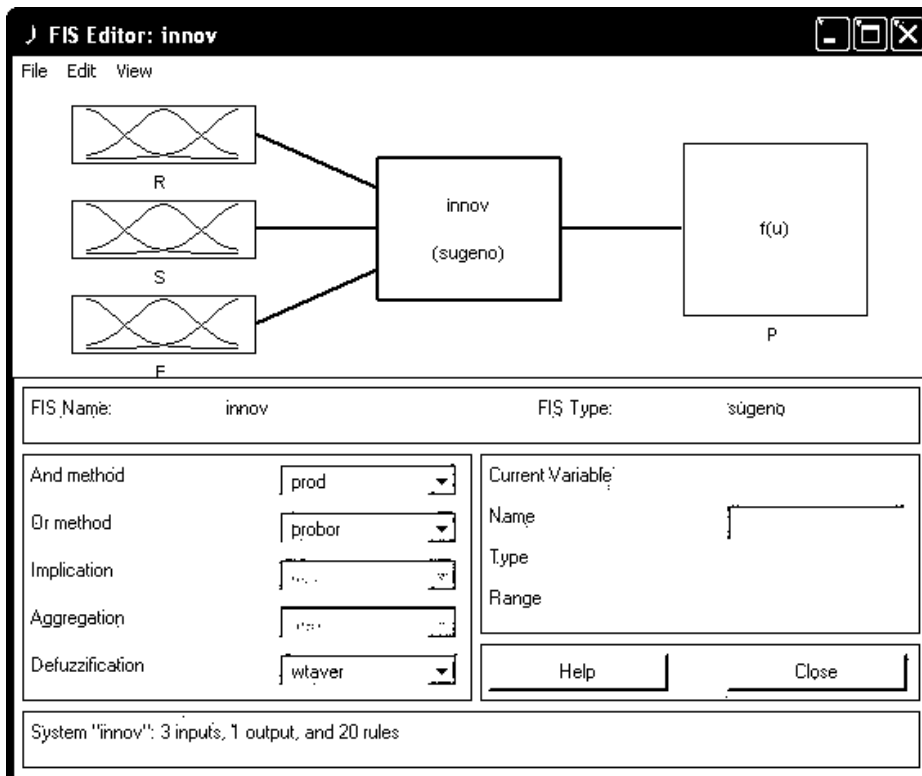
»
20

. 3.3.3.

L .

20

. 3.3.4.



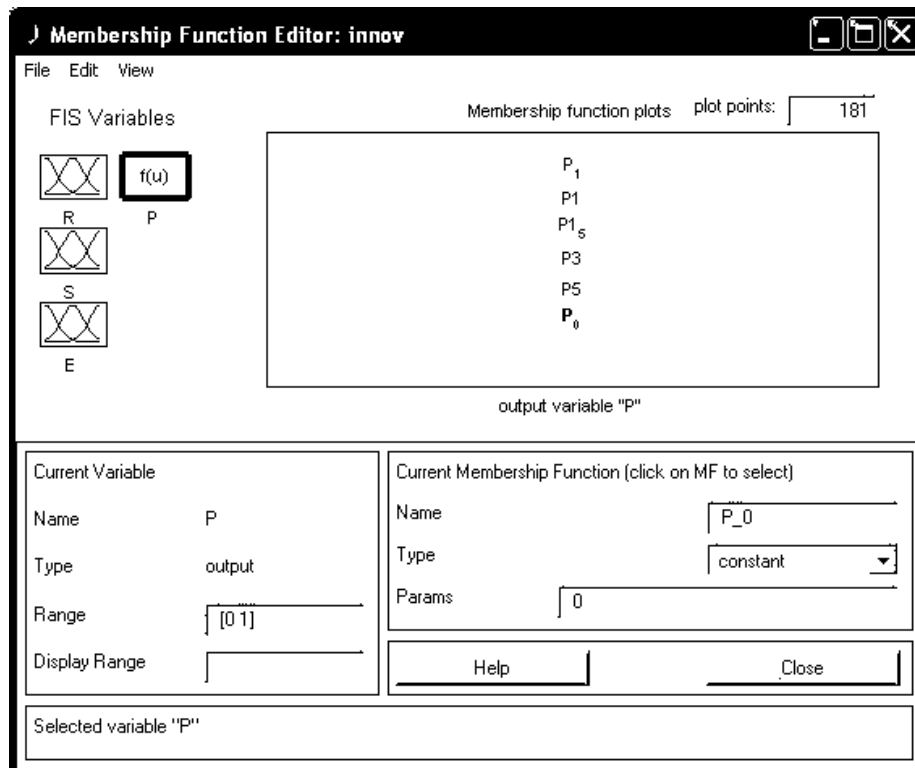
. 3.3.2.

FIS

mortgage

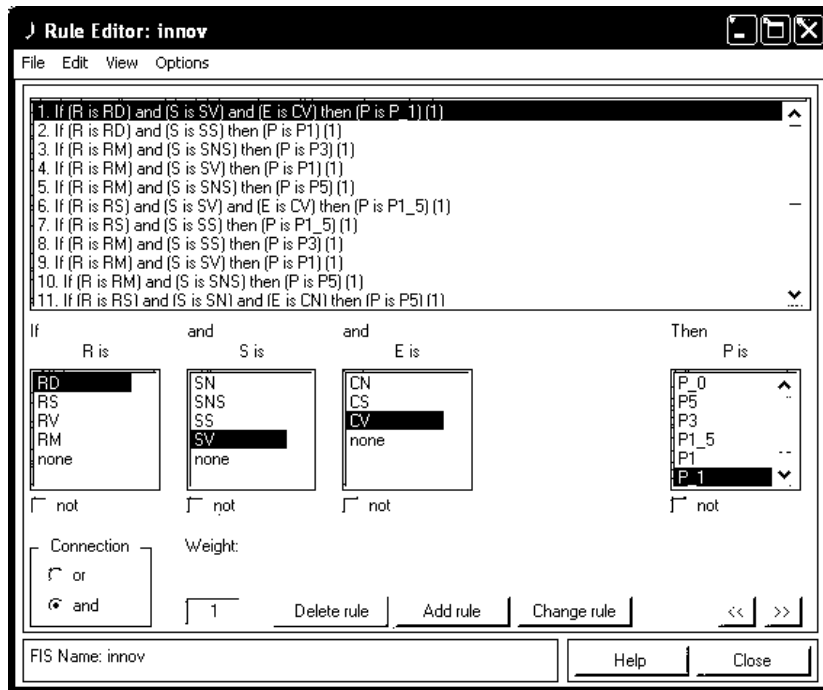
MATLAB

« » 0.08, 0.48 ,
« » 900.
MATLAB
« -
» 50,6 % (. 3.3.5).
-
-
»

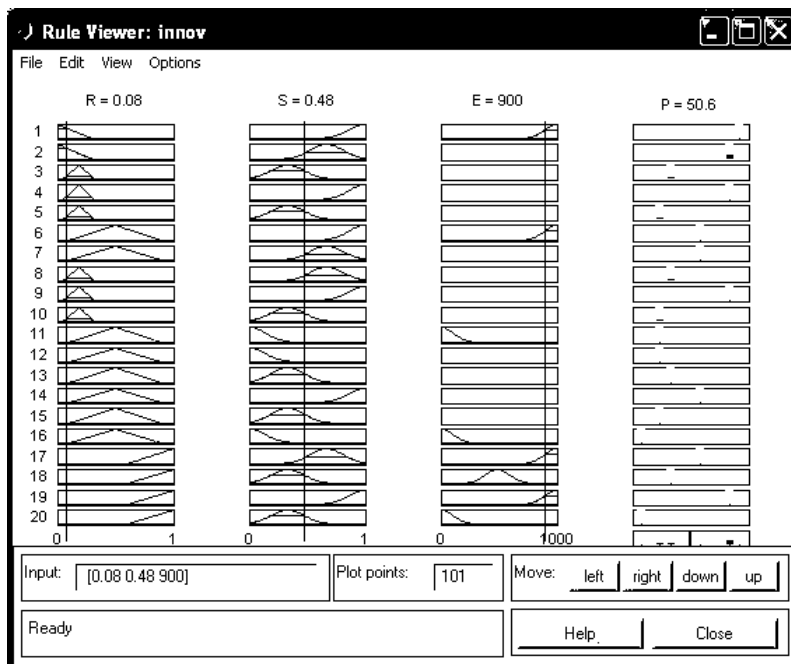


. 3.3.3.

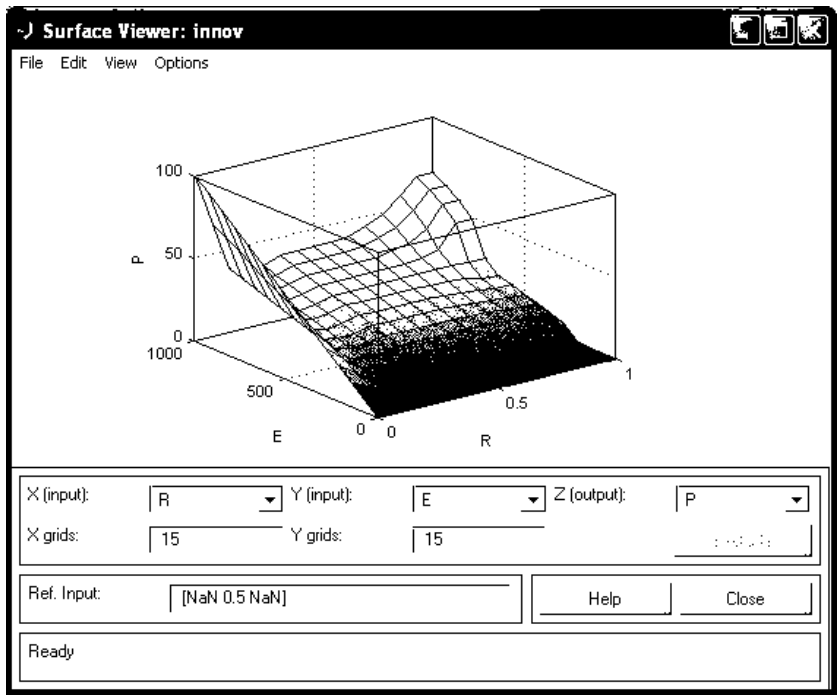
(. 3.3.6).



. 3.3.4.



. 3.3.5.



• 3.3.6.

» (Location) 1 = {«
 », «
 1 = {PS, , }.

(Work-manship) 2
 = {«
 {PS, , }.

(Asset) 3 = {«
 », «
 3 = { S, , }.

(Income) T4 =
 {«
 { S, , }.

(Interest) T5 =
 {«
 , }.

» (Credit) T6 =
 {«
 T6 = {N , NS, Z, S, }.

, N.

1-40
 (« »),
 min-
 m - ,

(mortgag) L .

FIS 5

« (β3), « (β4), « (β5) » (β1), « (β2), « » (β6).

I, m (m), (min – (min), (centroid).

3.3.2

1	0.51	11	0.28
2	0.75	12	0.97
3	0.24	13	0.32
4	0.14	14	0.71
5	0.77	15	0.47
6	0.33	16	0.69
7	0.79	17	0.96
8	0.16	18	0.74
9	0.86	19	0.86
10	0.98	20	0.11
21	0.53	31	0.05
22	0.09	32	0.03
23	0.81	33	0.49
24	0.70	34	0.68
25	0.06	35	0.27
26	0.58	36	0.40
27	0.78	37	0.59
28	0.91	38	0.14

29	0.17	39	0.75
30	0.34	40	0.59

3.4

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1) , -

2) ;

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3) ;

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, « »

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?».

[0,1].

() .

()

$$A = \{a_1, a_2, \dots, a_n\},$$

$$P = \{p_1, p_2, \dots, p_q\},$$

A.

$$a_i \in A$$

$$x_i = \{x_i^1, x_i^2, \dots, x_i^q\},$$

$$x_i^j \in R -$$

$$p_j \in P$$

$$a_i \in A.$$

— (,)

(, , , ...);
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$$x_i^j \in R$$

$$x_i = \{x_i^1, x_i^2, \dots, x_i^q\}$$

D (n*q),
 x_i .

$$R(A) = \{A_k \mid A_k \subseteq A\}$$

$$J(A) = \{A_k \mid A_k \subseteq A\}$$

$$A_k (k \in \{2, \dots, c\}),$$

$$F(R(A))$$

$$F(J(A))$$

fcM MATLAB,

$$F(J(A))$$

$$A_k (k \in \{2, \dots, c\}),$$

$$\sum_{k=1}^c \mu_{A_k}(a_i) = 1, (\forall a_i \in A), \quad (3.1)$$

$$A_k (k \in \{2, \dots, c\}),$$

$$v_k \quad A_k (k \in \{2, \dots, c\}),$$

$$v_j^k = \frac{\sum_{i=1}^n (\mu_{A_k}(a_i))^m x_i^j}{\sum_{i=1}^n (\mu_{A_k}(a_i))^m}, (\forall k \in \{2, \dots, c\}, \forall p_j \in P), \quad (3.2)$$

m -

(m > 1).

$$v_k = (v_k^1, v_k^2, \dots, v_k^q)$$

R^q ,

$$F(A_k, v_k^j) = \sum_{i=1}^n \sum_{k=1}^c (\mu_{A_k}(a_i))^m \sum_{j=1}^q (x_i^j - v_k^j)^2. \quad (3.3)$$

$$m > 1.$$

$$c \in N, c > 1,$$

$$m,$$

$$U$$

,

$$a_i \in A$$

$$A_k (k \in \{2, \dots, c\}),$$

(4.3)

(4.1)–(4.2),

:

$$\sum_{i=1}^n \mu_{A_k}(a_i) > 0, (\forall k = \{2, \dots, c\})$$

$$\mu_{A_k}(a_i) \geq 0 (\forall k = \{2, \dots, c\}, a_i \in A)$$

(3.4)

(4.4)

(4.3) –

fuzzyISODATA. 1980

FCM, Fuzzy-C-Means.

MATLAB.

FCM

$$R(A) = \{A_k \mid A_k \subseteq A\},$$

FCM

FCM

1. :

$$s \in N,$$

$$\varepsilon \in R_+,$$

$m > 1.$

D

$$R(A) = \{A_k \mid A_k \subseteq A\}$$

$$\mu_k(a_i), \forall k \in \{2, \dots, c\}, \forall a_i \in A.$$

2.

$$R(A) = \{A_k \mid A_k \subseteq A\}$$

(6.2)

$$v_k^j, (\forall k = \{2, \dots, c\}, \forall p_j \in P)$$

(6.3).

1.

3.

$$R'(A) = \{A_k \mid A_k \subseteq A\}$$

$$\mu_k^1(a_i), \forall k \in \{2, \dots, c\}, \forall a_i \in A,$$

:

$$\mu_k^1(a_i) = \left(\frac{\left(\sum_{j=1}^q (x_i^j - v_k^j)^2 \right)^{\frac{1}{2}}}{\left(\sum_{j=1}^q (x_i^j - v_l^j)^2 \right)^{\frac{1}{2}}} \right)^{\frac{2}{m-1}}, \forall k \in \{2, \dots, c\}, \forall a_i \in A$$

4. $\mu_k^1(a_i) = 1, \quad k \in \{2, \dots, c\} \quad a_i \in A$

$$\sum_{j=1}^q (x_i^j - v_k^j)^2 = 0,$$

$A_k \quad \mu_k^1(a_i) = 1,$

$A_l (\forall l = \{2, \dots, c\}, l \neq k) \quad \mu_l^1(a_i) = 0.$

$k \in \{2, \dots, c\} \quad a_i \in A,$

$\mu_k^1(a_i) = 1, \quad \mu_l^1(a_i) = 0.$

5. $R'(A) = \{A_k \mid A_k \subseteq A\}$

(6.2)

(4.3).

6. $\varepsilon \in R_+, \quad s$

$R'(A) = \{A_k \mid A_k \subseteq A\}$

$R(A) = R'(A) \quad 3,$

1

$R^*(A),$

$\mu_k(a_i),$

$v_k = (v_k^1, v_k^2, \dots, v_k^q).$

FCM

MATLAB

fcn

:

$[center, U, obj_fcn] = fcm(data, cluster_n)$

$[center, U, obj_fcn] = fcm(data, cluster_n, options)$

– data: D , $a_i \in A$

$$x_i = \{x_i^1, x_i^2, \dots, x_i^q\};$$

– cluster_n: $c \in N, c > 1$.

– center: v_k

$$v_k = (v_k^1, v_k^2, \dots, v_k^q);$$

– U: $\mu_k(a_i), \forall k \in \{2, \dots, c\}, \forall a_i \in A;$

– obj_fun: (3)

options, fcm()

– option (1): m
 $U(m = 2);$

– option (2): $s(100);$

– option (3): $\epsilon(0.00001);$

– option (4): $(, 1).$

NaN (),

1.

MATLAB.

fcmdata.dat,

D

140

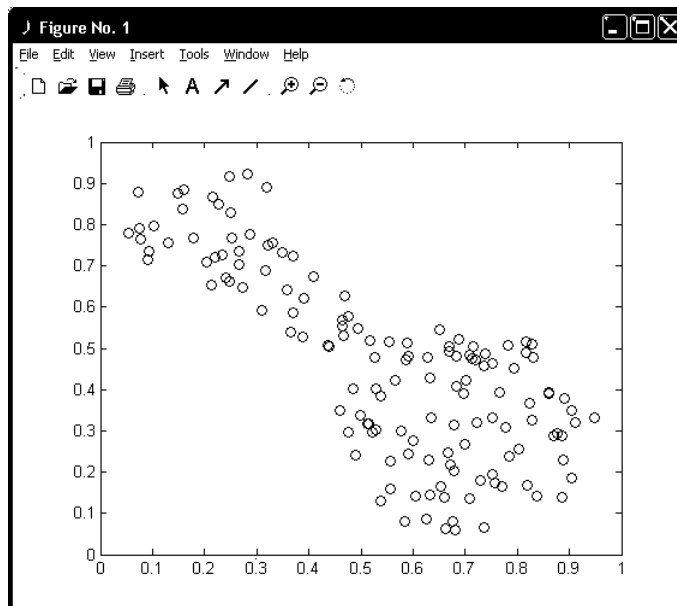
2

1.

Load fcmdata.dat

plot(fcmdata(:,1), fcmdata(:,2), 'o')

. 3.4.1.



. 3.4.1.

D

fcmdata.dat

2.

fcmdata,

:

[center, U, obj_fcn]=fcm(fcmdata, 2).

—
—
—

— obj_fcn.

center;

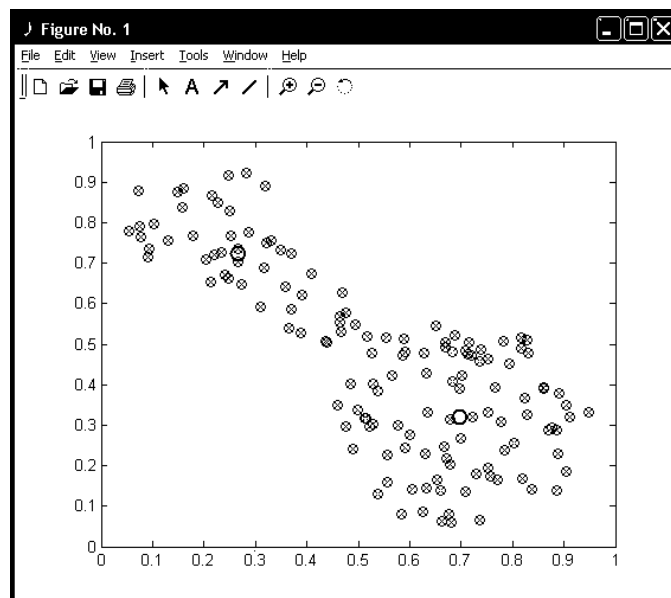
— U;

```

load fcndata.dat
plot(fcndata(:,1), fcndata(:,2),'o')
[center, U, obj_fcn]= fcm(fcndata, 2);
maxU=max(U);
index1 = find(U(1,:)== maxU);
index2 = find(U(2,:)== maxU);
line(fcndata(index1,1), fcndata(index1,2),'linestyle','none',...
'marker', 'x', 'color', 'g');
line(fcndata(index2,1), fcndata(index2,2),'linestyle','none',...
'marker', 'x', 'color', 'r');
hold on
plot( center(1,1), center(1,2),'ko', 'markersize',10, 'LineWidth', 2)
plot( center(2,1), center(2,2),'ko', 'markersize',10, 'LineWidth', 2)

```

. 3.4.2.



. 3.4.2.

3.

MATLAB

center U,

Enter.

4. ,
:
[center, U, obj_fcn] = fcm(fcndata, 2, [2.5 1000 0.000001 1]);
2.5,
1000, $\epsilon = 0.000001$.

fcm,

5. ,
MATLAB

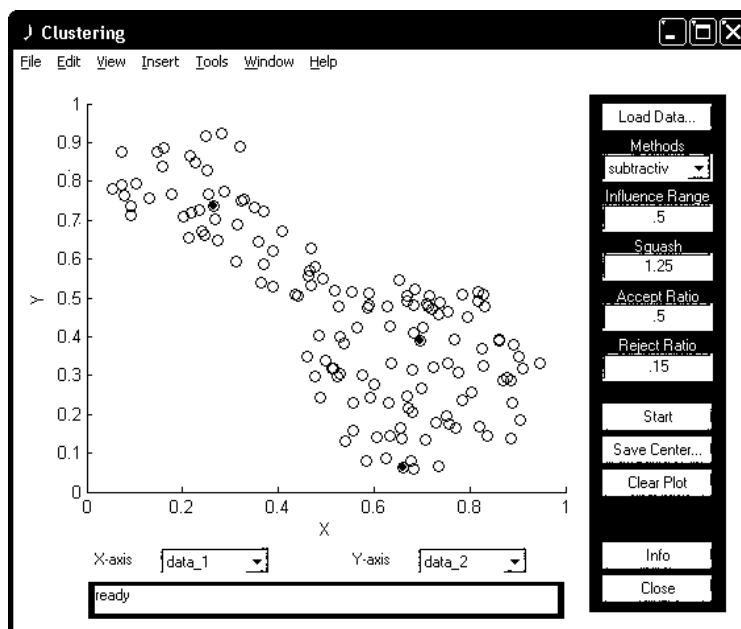
findcluster.

(subtractive clustering,
subclust).

6.

: **findcluster**

findcluster('file.dat').



. 3.4.3.

Methods,
Start.

6.

1)

2)

radii,

radii

[C, S] = subclust (X, radii, xBounds, options)

radii

[0,1]

radii

radii 0.2 0.5.

xBounds

(2xq),

q -

```

options,
:
- options(1) = guashFactor -
radii
( 1.25);
- options(2) = acceptRatio -
0.5);
- option(3) = rejectRation -
0.15);
- options(4) = verbose -
0,
( 0).
subclust

```

Load fcmdata.dat

```

[C, S] = subclust(fcmdata, [0.5 0.5], [], [1.25 0.5 0.15 1])
- 0.5 0.5.

```

. 4.3,

suclust

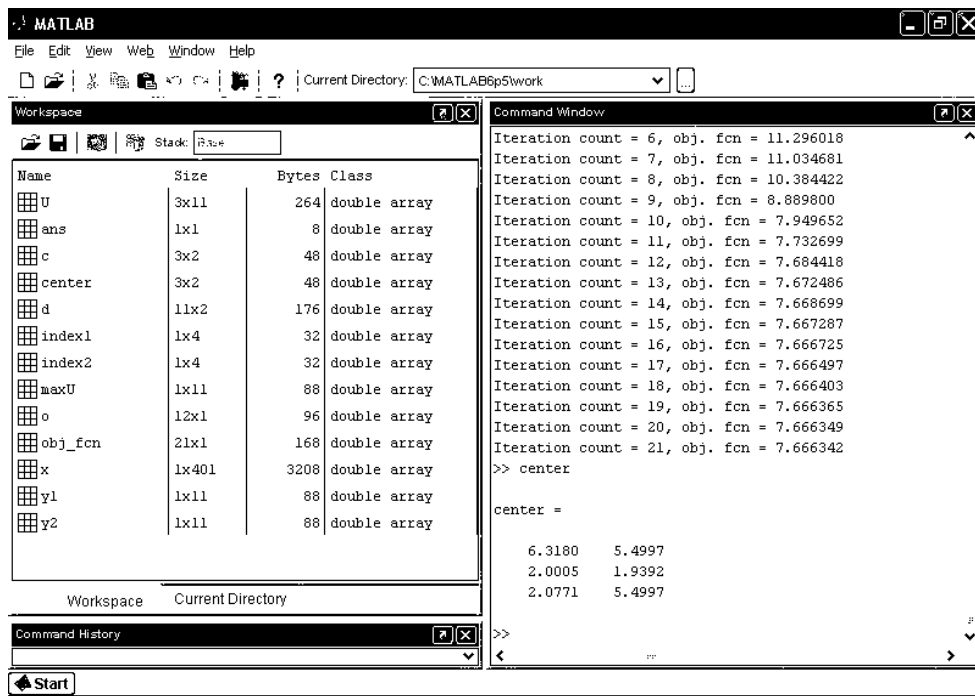
findcluster.

MATLAB

1. $(1,2); (2,1); (1, 2); (3,2); (2,3); (1,6); (2,5); (3,6); (5,5); (5,6); (7,5); (7,6).$

3

. 3.4.4.



. 3.4.4.

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2.

10

(2, 3 4).

- , - . :

1		100	120	300	250	200
		0,1	0,3	0,2	0,2	0,2
2		120	400	200	150	300
		0,2	0,4	0,1	0,2	0,1
3		200	250	260	150	300
		0,3	0,3	0,2	0,1	0,1
4		120	100	200	150	130
		0,2	0,4	0,2	0,2	0,2
5		520	400	250	450	300
		0,6	0,1	0,1	0,1	0,1
6		520	400	200	450	300
		0,2	0,4	0,1	0,2	0,1
7		220	300	200	150	300
		0,2	0,3	0,2	0,2	0,1
8		100	300	200	150	300
		0,2	0,2	0,3	0,1	0,2
9		230	400	200	250	200
		0,1	0,3	0,2	0,2	0,2
10		220	120	200	350	400
		0,1	0,5	0,1	0,2	0,1

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4

1. () .
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6. .

1. ()

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2. , (—) —

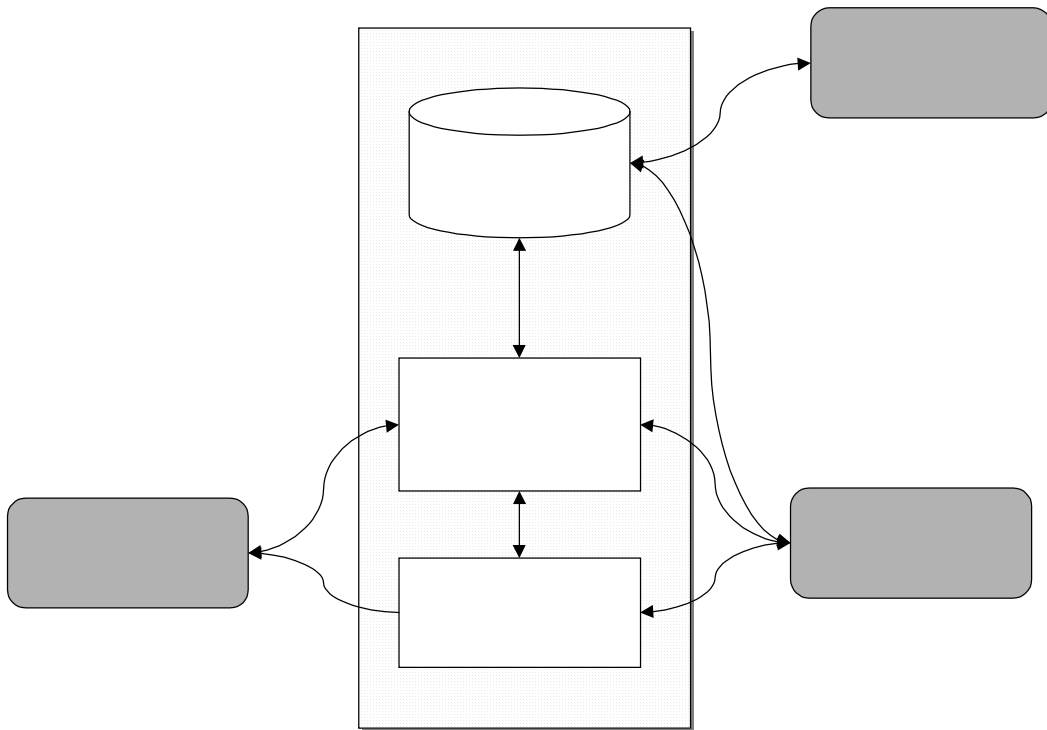
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(.7.7):

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 , Web- . Web-
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1. ?
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5

WEB

1. Web.
2. .
3. .
4. -
5. .
6. .
7. .
8. .

1. Web

1. « » -
2. , -
3. , , -
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[4].
(.- . « » — « », « » — « », « ») — ,
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, FIPA (Foundation for Intelligent
Physical Agents): — ,
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:
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, , ,

$\mathcal{O} = \langle X, \mathcal{R}, \Phi \rangle$

2.

$\mathcal{O} = \langle X, \mathcal{R}, \Phi \rangle$
 $\mathcal{R} / \mathcal{O}$

$$\Phi = \emptyset \quad \mathfrak{R} = \emptyset,$$

$$: \quad \mathbf{O} = \mathbf{V} = \langle \mathbf{X}, \{ \}, \{ \} \rangle.$$

), (,) . -

$$\mathfrak{R} = \emptyset, \quad \Phi \neq \emptyset,$$

f Φ .

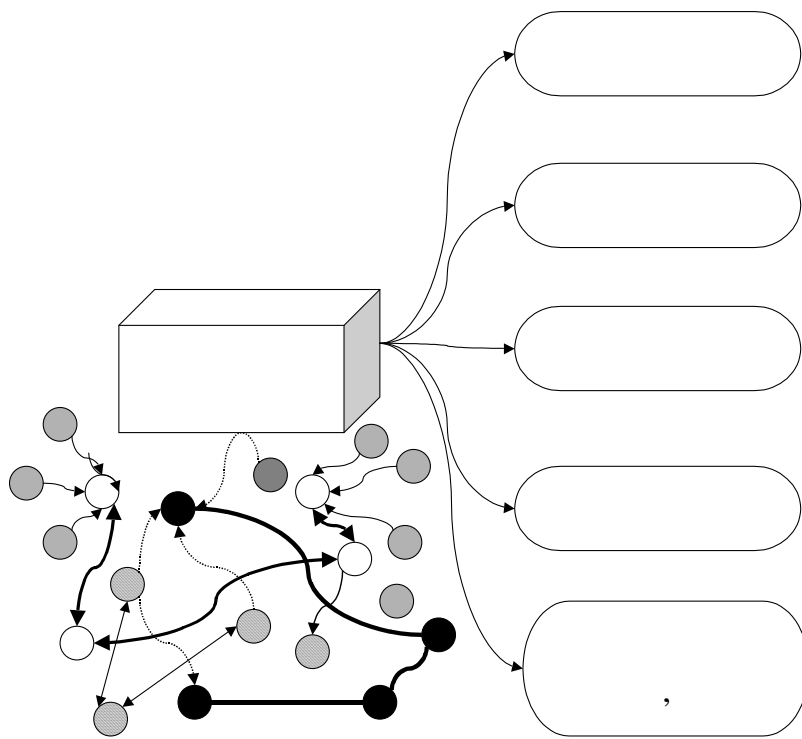
$$\mathbf{O} = \mathbf{T}^0 = \langle \mathbf{X}, \{ " \quad - \quad - \quad " \}, \{ \} \rangle.$$

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. 5.1.



. 5.1.

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 , IDEF5 (INTEGRATED
 DEFinition), :
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 4) ; –
 5) –
 . :
 TOVE (Toronto Virtual Enterprise), Ontolingua, KACTUS (ESPIRIT), SHOE (Simple HTML Ontology Extensions), Plinus, yc (MCC), ()², Semantic Web (W3C) .
 Web
 Semantic Web –
 OWL (OWL Web Ontology Language),
 DAML+OIL Web Ontology Language RDF
 (Resource Description Framework). OWL –
 , OWL
 : (headers), (class
 elements), (property elements)
 (instances), –
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()² -

()²

- (ontological engineering);
- Web- ;
- Web-

Web-

SHOE

Web-

SHOE

(reusable ontologies)

Web-

(Knowledge Annotator).

4.

(- DL)

DL

Semantic Web

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DL

DL -

NC;

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NR.

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 - DL, ()
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 DL
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 XML-
 Semantic Web, XML
 Semantic Web. 1
 XML-
 RDF(S)
 XML-
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SPARQL.

Semantic Web

OWL;

Ontolingua.

– *Protégé, Chimaera*
Protege.

, , (XML)
(OWL-RDF).

Protégé –

, Protégé,
Protégé.

Protégé-Frames

Protégé-OWL.

Protégé

Protégé, ,
RDF OWL. -
Protégé , . Protege -
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Protégé Frames -
Protégé. -
OKBC (Open Knowledge
Base Connectivity). -
, ,
OWL, W3C. -
<X,RF) , ,
, ,
Protégé. ,
Protege , -
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OWL, , , -
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Protégé -
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HermiT, Snorocket, , , -
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7.

(ontology engineering) (ontology building),
- -
(ontology learning).
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: Cyc method, Methology

by Uschold King, METHONTOLOGY, On-To-Knowledge

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(Sensus, Kaktus, Uschold and King, Gruninger and Fox, Noy and McGuinness),

-

(Methontology, OTK, UPON).

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HCOME DILIGENT),

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IDEF5

SADT

(Structured Analysis and Design Technique)

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IDEF_x

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 . SADT ,)
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 IDEF5, ,

METHONTOLOGY

METHONTOLOGY

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METHONTOLOGY

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(TextToOnto, Text2Onto, OntoLT, OntoLearn).

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:
Text2Onto, OntoLT, OntoLearn). (TextToOnto,

(PROMPT, AnchorPROMPT, GLUE, FCAMerge).

API, (, Web-)

8.

- 1) :
- 2) ;
- 3) ;
- 4) ;
- 5) ;
- 6) ;

OWL 2.0.

- 1. Web.
- 2. -
- 3. ?

4.

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8.

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6

SEMANTIC WEB

1. Semantic Web.
2. Semantic Web.
3. Resource Description Framework (RDF) Web Ontology Language (OWL) – , Semantic Web.

1. Semantic Web

Semantic Web

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. Semantic Web -
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. Semantic Web -
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- Web ,
; ;
- (discovery) Web- ;
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- -

2. Semantic Web

Semantic Web

. Semantic Web

:

- RDF;
- OWL;
- SPARQL – RDF;
- SWRL.

Semantic Web

«data-centric»

Semantic Web –

Semantic Web

Semantic Web –

Semantic Web

Web

Semantic

Web

().

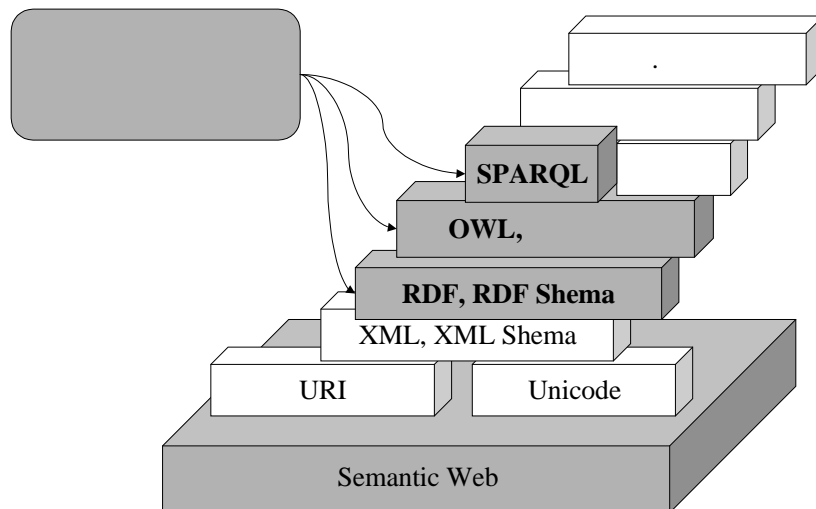
Semantic

(URI), Sema-

tic Web

Web, –
tic Web,

:
 Semantic Web,
 Semantic Web, (
), Semantic Web,
 Semantic Web.
 Semantic
 Web,
 Semantic Web
 Semantic Web Web- :
 WWW.
 WWW
 Semantic Web
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 Semantic Web
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. 6.1. Semantic Web

Semantic Web

Semantic Web

Web-

Semantic Web –

Web-

(knowledge representation, KR),

(artificial intelligence, AI),

3. Resource Description

Framework (RDF) Web Ontology Language (OWL) –

Semantic Web

Resource Description Framework (RDF)

Web Ontology Language (OWL) –

Semantic Web,

Web-

RDF

BI 2.0

Semantic Web (. 3):

Resource Description Framework (RDF);

Web Ontology Language (OWL);

SPARQL (SQL like query language for RDF).

RDF

RDF (Resource Description Framework) –

1999

W3C

	RDF –		« ’	-
		»		-
			, RDF	-
				-
		XML Schema		-
		, RDF Schema		-
		RDF (, authorOf)	-
				-
		RDF Schema		-
		RDF.		-
		Class, subPropertyOf	subClassOf,	-
			RDF	-
		RDF (XML –	-
XML).				-
	2.0	RDF		-
				-
			Oracle	-
		100		-
			Semantic Web,	-
	Oracle	Oracle Database	10g Enterprise	-
Edition.		Java-		-
		Oracle 10g	RDF.	-
		Oracle	2005	-
	RDF	Spatial 10.2g		-
RDF.			RDF	-
				-
		Web.	Microsoft	-
Services Framework 3.0 Developer Guide	2006			-
	RDF			:
1) RDF				-

; 2)

Web-

OWL

OWL (Web Ontology Language)

OWL Web,
URI. OWL
XML, RDF, RDF Schema DAML+OIL.

XML- DTD (Document Type Definition)

XML-
2.0 OWL

SPARQL

RDF, RDF, SQL
SPARQL RDF Query Language
SPARQL

RDF

SPARQL,

Web-

« »

(SPARQL)

SPARQL – , RDF.
 SPARQL
 RDF -
 SPARQL,
 Web- ,
 (,
 SPARQL)
 SPARQL ,
 Web 2.0:
 Web 2.0. SPARQL
 , RDF -
 RDF -
 (middleware). SPARQL 2.0

1. Semantic Web?
2. Semantic Web?
3. Resource Description Framework (RDF) Web Ontology Language (OWL) – , -
 Semantic Web?
4. RDF?
5. OWL?
6. SPARQL – RDF?
7. SWRL?

DATA MINING

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Data Mining.

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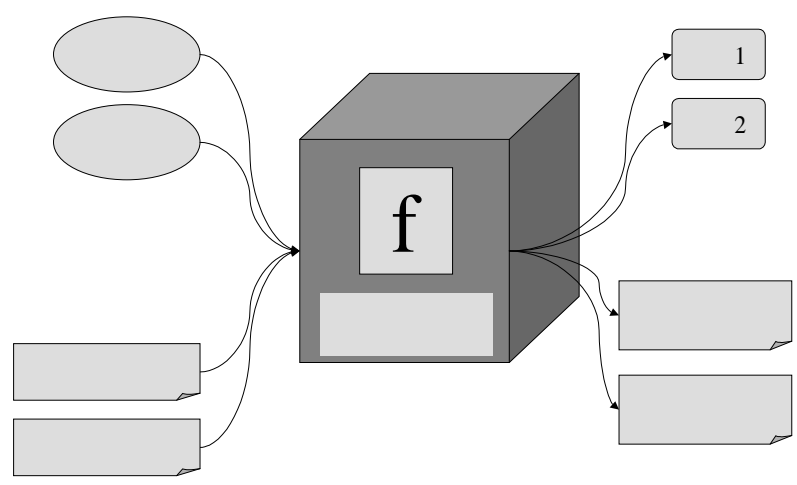
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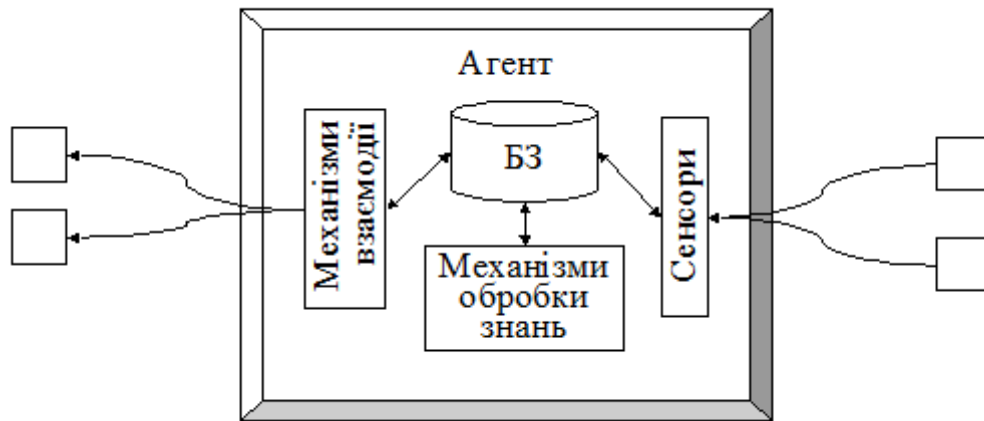


.7.1.

FIPA (Federation of Intelligent Physical
 Agents), - , -
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 . FIPA - , 1996 -
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 - (reactivity) -
 ;
 - (autonomy) -
 ;
 - (collaborative behavior) -
 ;

– («knowledge level»
 communication ability) –
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 – (inferential capability) –
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 – (temporal continuity) – -
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 – (personality) –
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 – (adaptivity) –
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 – (mobility) –
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 (autonomy) – -
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 (social ability) – -
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(reactivity) –
;
(pro-activity) –



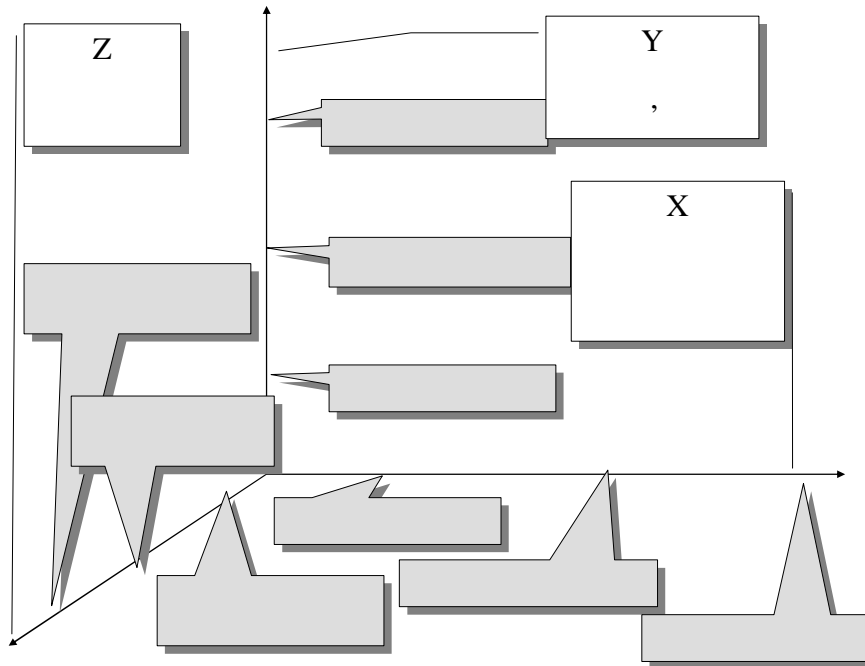
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Data Mining,

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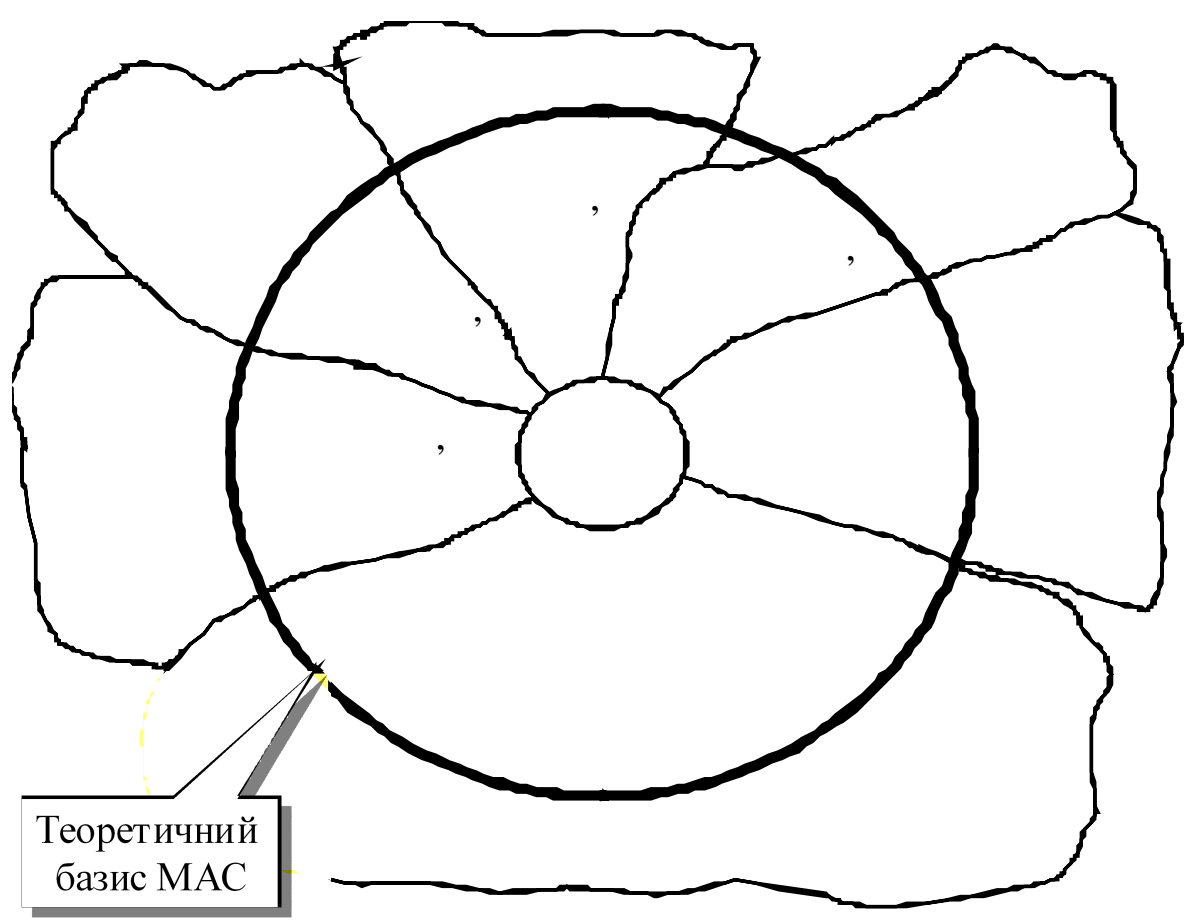
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master-slave client-server.

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KSE –

KSE

: Interlingua, Shared Reusable Knowledge Bases, External Interfaces. *Intrelingua*

KIF (Knowledge Intrchange Format). KIF

(<http://www.cs.umbc.edu/kse/kif/>). *SRKB* (Shared Reusable Knowledge Bases)

External Interfaces

KIF

. KIF

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«'» «»,»,

. KIF

KIF ()

KQML –

KQML:

- KQML
- (performatives) –

- KQML,

KQML

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(KQML

ASCII).

KQML (

KQML
KQML.

(,).

KQML

KQML

6.

Data Mining).

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(\quad , \quad) .

A_i A_j

A_i $A_j, j = \overline{1, n}$

A_j ;

A_j C_j ;

A_j A_i :

S_k $\langle S_k, P, A_j \rangle$, A_j

A_i $A_j, j = \overline{1, n}$.

(\quad) .

Data Mining

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Web-

on-line;

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- 6.
- 7.
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FIPA?

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8 WEB-

1. - .
2. Web- .
3. Web- .
4. .

1. -

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COA ,
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SOA - ,
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SOA
50- ;
Web-
SOA ()
SOA - Web-
SOA
SOA
SOA
SOA
XML-
XML-

2. Web-

Web- 90- XX .

Web-

, IBM, Microsoft, Ariba, Sun

Microsystems, SAP

W3C. W3C

Web Services Architecture Working

Group,

Web-

Web-

XML

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Internet. Web-

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URI,

XML.

Web-

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: SOAP (Simple

Object Access Protocol) -

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WSDL -

Web-

; UDDI

(Universal Description, Discovery and Integration) -

Web-

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Web-

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- WSDL-

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Web-

SOAP,

XML

Web-

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Web-

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UDDI.

Web-

- UDDI DISCO. UDDI -

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. UDDI -

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Internet.

SOAP

Web-

GET,

POST,

SOAP.

SOAP – Microsoft Internet, (RPC, Remote Proc dure Call) XML. XML, SOAP XML-« » WSDL WSDL – XML W3C. Web- WSDL Web- WSDL Microsoft – SOAP Toolkit 2.0 (WSDL Generator) IBM – WSDL Toolkit. Web- (Web Services Description Language (WSDL)) Web- UDDI UDDI Web- UDDI (UDDI Business Registry), Web- Business Registry, UDDI UDDI Web- OWLS. Web-

3.

Web-

Web-

Web-

Web-

Web-

Web-

WSDL, UDDI),

WSDL,

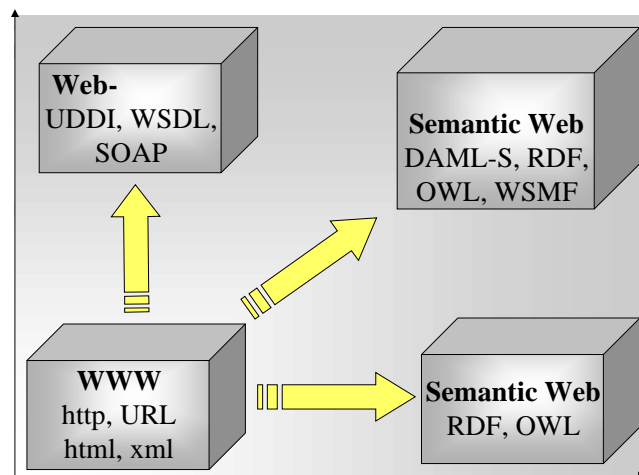
XML-

Web-

W3C

Web: RDF, RDF Schema, OWL

(. 8.1).



. 8.1.

Web-

OWL-S –

OWL-S

OWL-S

Web-

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OWL-S

Web-

OWL-S, Web-

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Web-

(matchmaking).

OWL-S

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OWL-S

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OWL-S

Web-

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Web-

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Web-

WSDL,

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OWL-S,

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(*binding*)

WSDL.

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OWL-S.

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UDDI,

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OWL-S (Web Ontology Language for Services) –

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: SERVICE

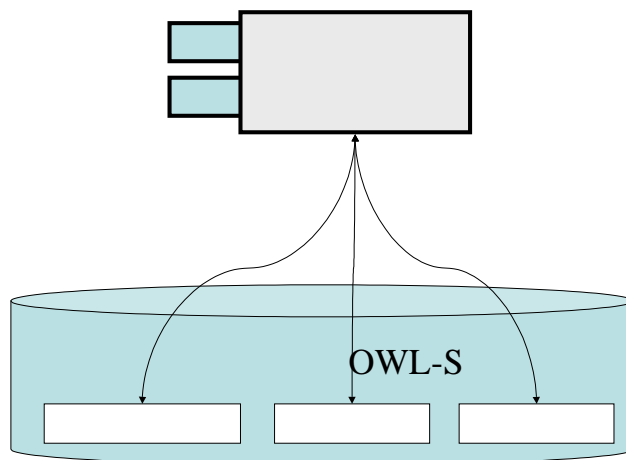
SERVICEPROFILE;

: SERVICE

SERVICEMODEL;

: SERVICE

SERVICEGROUNDING.



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Web-

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SERVICE. OWL-S, Web-

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(matchmaking). OWL-S

OWL-S

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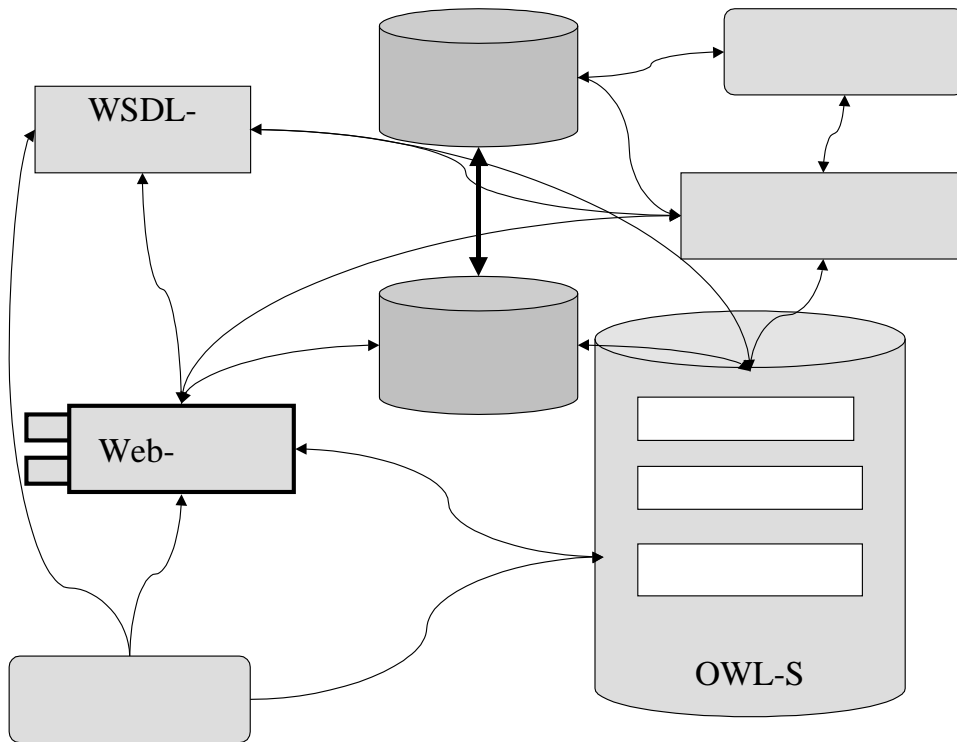
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Web- OWL-S Web- API

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1. Web- ?
2. SOAP XML?
3. Web- WSDL?
4. UDDI Business Registry?
5. Web- ?
6. OWL-S?
7. OWL-S?

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Fuzzy Logic Toolbox

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x_i

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w_i ,

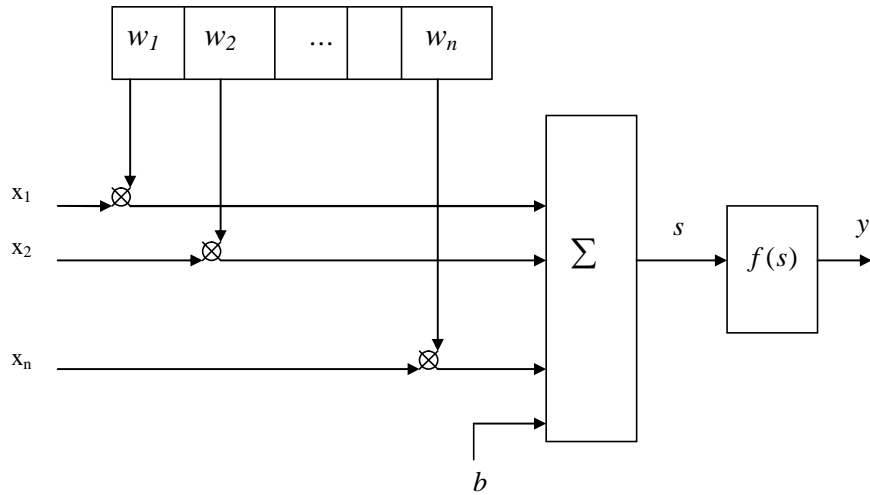
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. 9.1.

$$s = \sum_{i=1}^n w_i \cdot x_i + b; \tag{9.1}$$

$$y = f(s),$$

$w_i -$; $x_i -$; $b -$; $s -$ -

$(i \in \{1, 2, \dots, n\})$; - ; $n -$

; $f(s) -$ () -

: $w_i, x_i, b \in \mathfrak{R} (i \in \{1, 2, \dots, n\})$.

$w_i \in \mathfrak{R}_+ (i \in \{1, 2, \dots, n\})$, -

$w_i \in \mathfrak{R}_- (i \in \{1, 2, \dots, n\}) -$.

$$(9.1) \quad (6.1).$$

$x_i,$

y

$$(9.1).$$

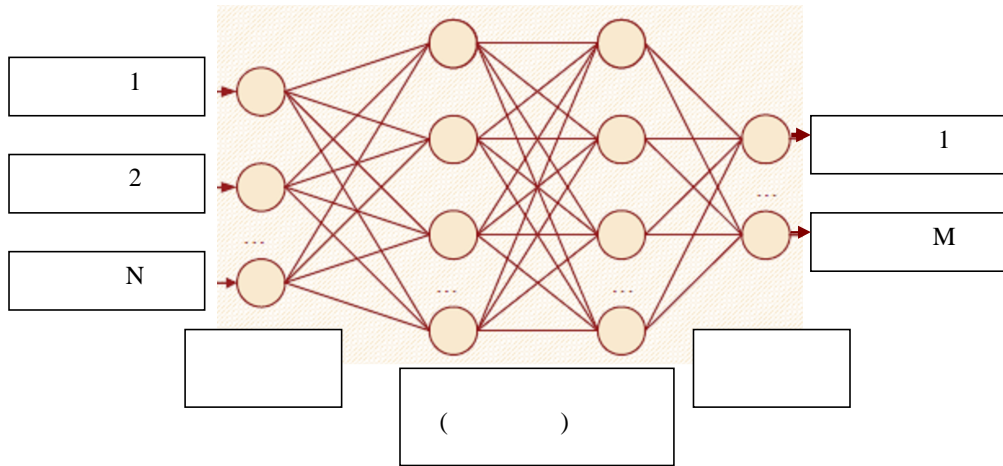
9.1

	\mathfrak{R}	$f(s) = k \cdot s$
	\mathfrak{R}_+	$f(s) = \begin{cases} 0, & s \leq 0 \\ k \cdot s, & s > 0 \end{cases}$
	$\{0, 1\}$	$f(s) = \begin{cases} 0, & s < T \\ 1, & s \geq T \end{cases}$
	\mathfrak{R}_+	$f(s) = s $
()	$\{-1, 1\}$	$f(s) = \begin{cases} -1, & s \leq T \\ 1, & s > T \end{cases}$
	\mathfrak{R}_+	$f(s) = s^2$
	\mathfrak{R}_+	$f(s) = e^{-a \cdot s}$
	$[-1, 1]$	$f(s) = \sin(s)$
()	$(0, 1)$	$f(s) = \frac{1}{1 + e^{-a \cdot s}}$
()	$(-1, 1)$	$f(s) = \frac{s}{a + s }$
()	$(-1, 1)$	$f(s) = \frac{e^{a \cdot s} - e^{-a \cdot s}}{e^{a \cdot s} + e^{-a \cdot s}}$
()	$[-1, 1]$	$f(s) = \begin{cases} -1, & s \leq -1 \\ s, & -1 < s < 1 \\ 1, & s \geq 1 \end{cases}$ $f(s) = \begin{cases} -1, & s \leq -1 \\ s, & -1 < s < 1 \\ 1, & s \geq 1 \end{cases}$
	$[0, 1)$	$f(s) = \begin{cases} 0, & s \leq 0 \\ s, & 0 < s < 1 \\ 1, & s \geq 1 \end{cases}$
	$[0, 1]$	$f(s) = \begin{cases} 1 - s , & s \leq 1 \\ 0, & s > 1 \end{cases}$
()	$(0, 1]$	$f(s) = e^{s^2}$

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(. 9.2).

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. 9.2.

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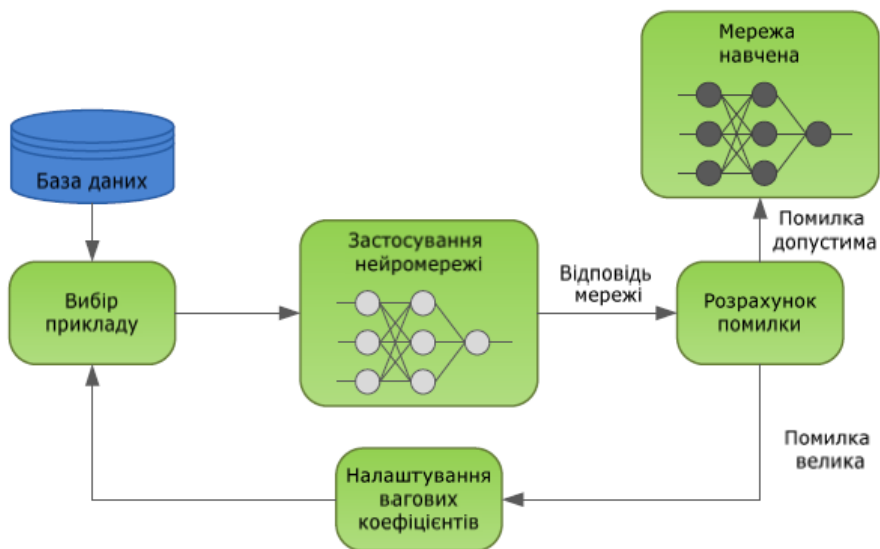
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. 9.3.

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1,1	0,67778
4	1
3,5	0,94444



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Resilient Propagation (Rprop) –

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Resilient Propagation

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(Self Organizing Maps – SOM),

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Fuzzy Logic Toolbox

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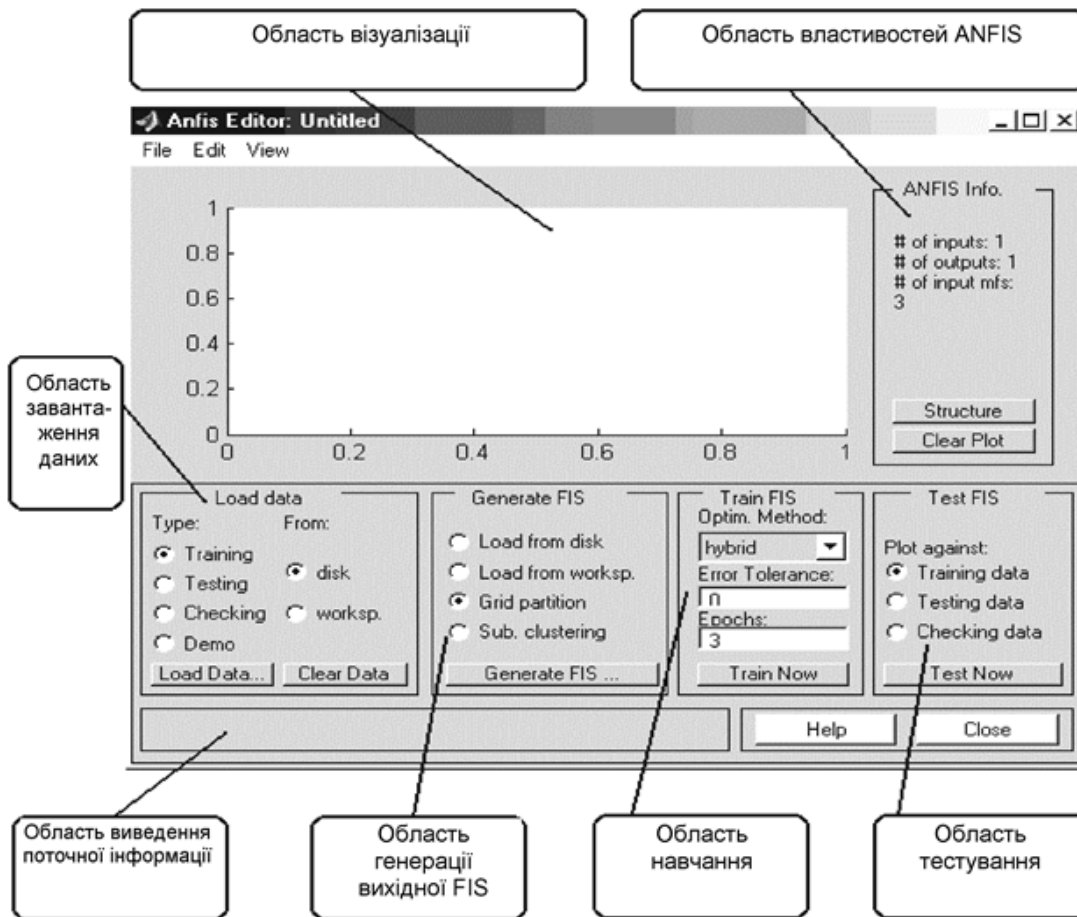
Fuzzy Logic Toolbox

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ANFIS.

ANFIS

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ANFIS-

ANFIS-

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– File, Edit View,
ANFIS,

Close,

Help
ANFIS-

Anfis

Edit:

Undo

Ctrl+Z.

FIS Properties...

FIS-

Ctrl+1.

Membership Functions...

Ctrl+2.

Rules...

Ctrl+3.

Anfis...

ANFIS-

Ctrl+3.

ANFIS-

Edit

GUI-

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ANFIS (ANFIS info)

Structure Clear Plot.

Structure

Clear Plot

(Load data)

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; Testing -

; Checking -

; Demo -

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(From),

(disk -

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worksp –                               MatLab);                               -
    Load Data...,                       ,                               -
    ,                                     ,                               -
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Data.                                     ;                               Clear
    (Generate FIS)                       -
    .                                     -
    : Load from disk –                   -
    ; Load from worksp. –                 -
    MatLab; Grid partition –              -
    (                                     ); Sub. clustering –         -
    .                                     .                               -
    Generate,                             -
    .                                     .                               -
    Load from disk ’                   -
    .                                     .                               -
    Load from worksp. ’                   -
    .                                     .                               -
    Grid partition ’                   -
    ,                                     ,                               -
    .                                     .                               -
    Sub clustering ’                   -
    : Range of influence –                 -
    ; Squash factor –                       -
; Accept ratio –                           ,                               -
    ,                                     ,                               -
    ,                                     ,                               -
    ; Reject ratio –                         ,                               -
    ,                                     ,                               -
    .                                     .

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(Train FIS) -
 (Optim. method), -
 (Error tolerance),
 (Epochs) Train Now, -

MatLab. ANFIS-
 : backpropa -
 ; hybrid -

(Test FIS)
 Test Now, -

- 1. ? -
- 2. -
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- 4. ? -
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- 7. ? -
- 8. ? -
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- 10. -
- ANFIS?

9.1

L

$$q = F(x_1, x_2) = 2\sqrt{x_1} \sqrt[4]{x_2},$$

(,) x_1 x_2 q

1.

1	2	2.37
4	1	4.00
1	4	2.82
5	5	6.68
2	4	4.00
4	3	5.26
3	1	3.46
4	4	5.65
4	2	4.80

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Matlab6,

train.txt.

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(Demo) –

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test.txt.

train.txt

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2	1	2.82
3	2	4.12
1	3	2.63
2	3	3.72
3	3	4.56
4	2	4.75
3	4	4.90

2.

ANFIS

(. 9.1.1).

Data

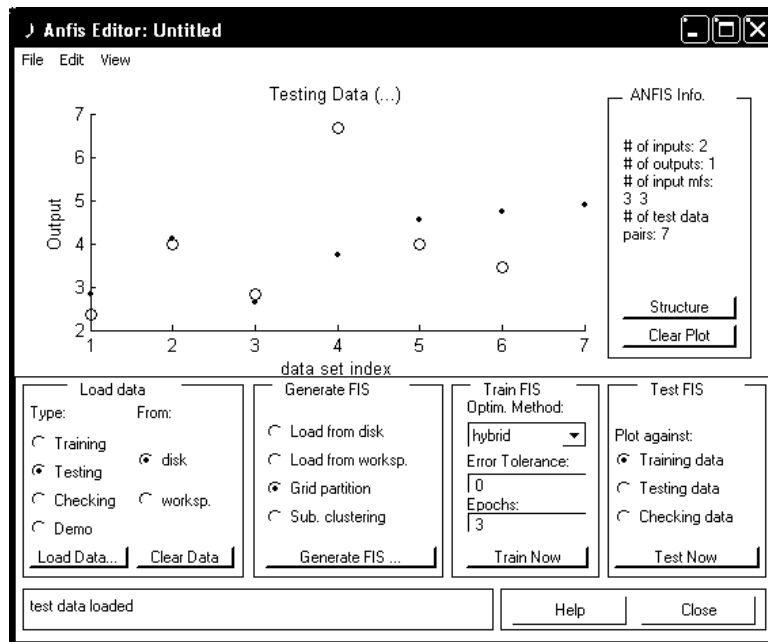
(worksp).

(train),

NFIS

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Load



. 9.1.1.

ANFIS

function.dat

testing,

Load data

test.txt.

3.

FIS.

(Load from disk),
worksp).

FIS
(Load from
FIS
(Grid partision)

(Sub. clustering).

Generate FIS

(. 9.1.2).

FIS.

INPUT

Number of MFs: 4 4

To assign a different number of MFs to each input, use spaces to separate these numbers.

MF Type: trimf, trapmf, **gbellmf**, gaussmf, gauss2mf, pimf, dsigmf, psigmf

OUTPUT

MF Type: constant, linear

Cancel OK

. 9.1.2.

Structure

FIS

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(Epochs) –

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Trian Now.

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Fuzzy

Logic Toolbox.

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ANFIS.

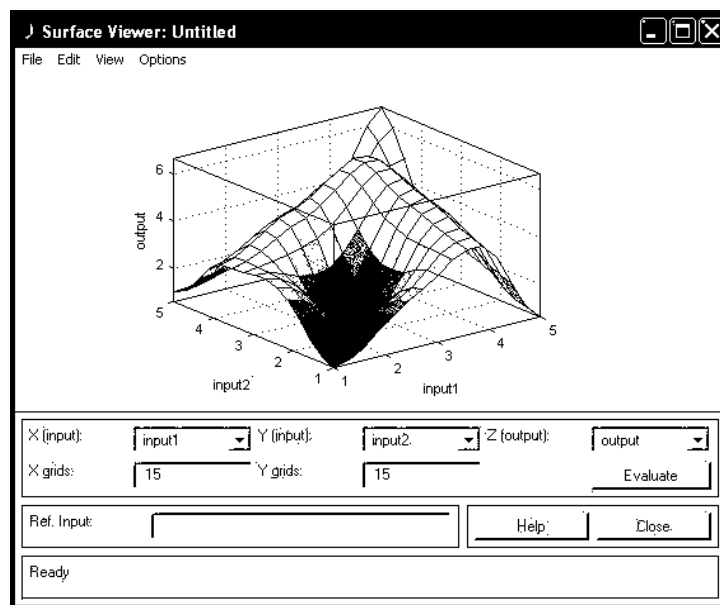
Editor),

(Membership Function
(Rule Editor),
(Rule

Viewer)
(Surface Viewer).

6.

*.fis
fuzzyToolbox (. 9.1.3).



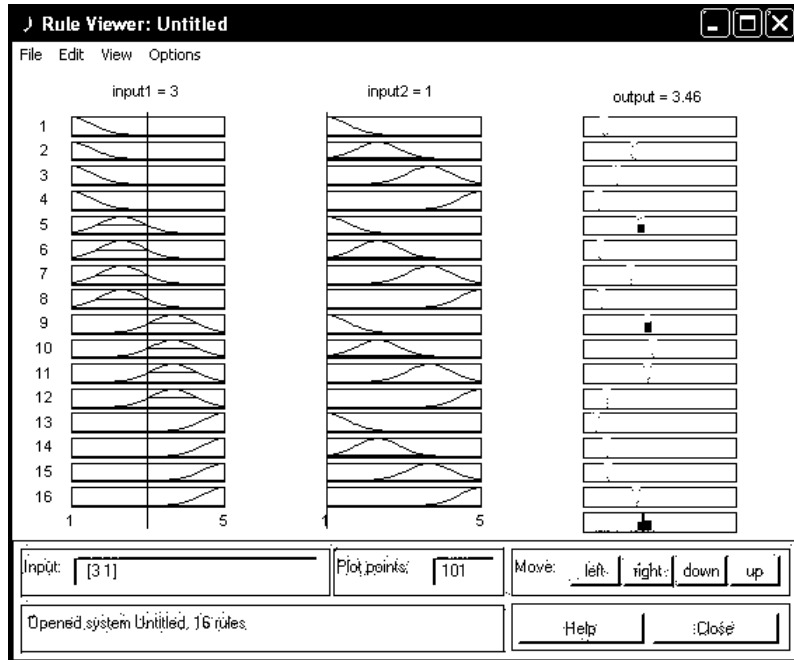
. 9.1.3.

$$q = F(x_1, x_2) = 2\sqrt{x_1} 4\sqrt{x_2}$$

(. 9.1.4).

Input (

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 (3.46).
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. 9.1.4.

4 3,
 5.45 (5.26).

1.

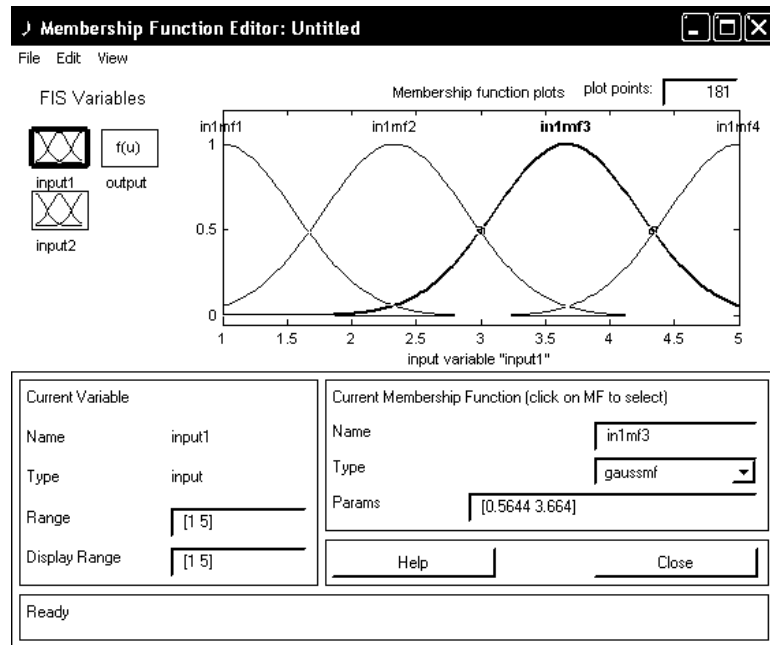
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. 9.1.5.

Params

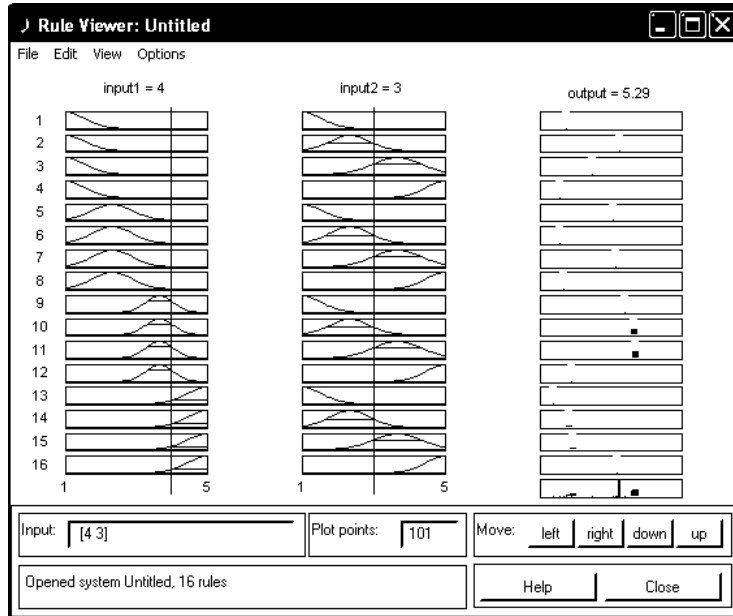
[0.385 3.66]

5.29 (. 9.1.6).

train.txt.

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2	1	2.82
3	2	4.12
1	3	2.63



. 9.1.6.

Clear Data

FIS
(gbellmf).

FIS,

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$$y = x^3,$$

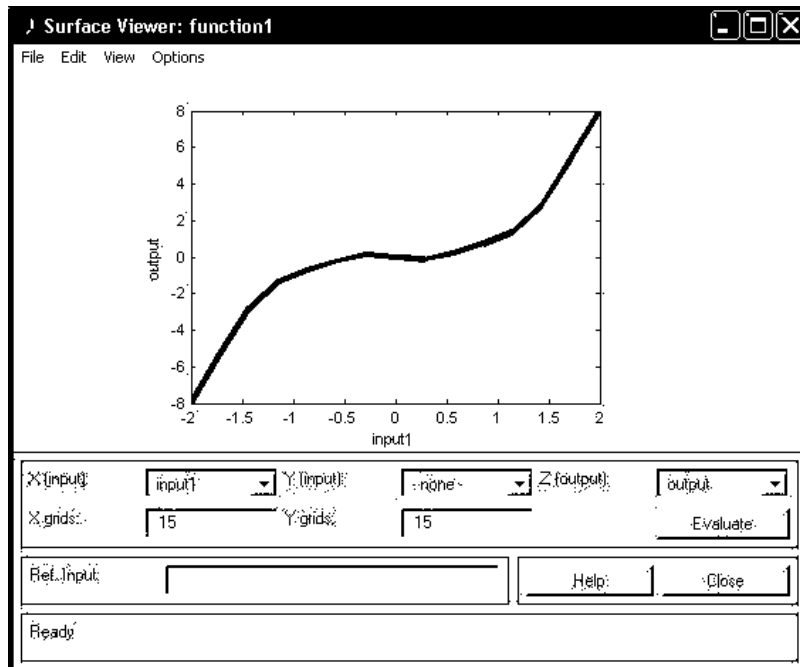
. 9.1.7 . 9.1.8.

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D:\MATLAB6p5\work\function2.dat
File Edit View Text Debug Breakpoints Web Window Help
Stack: Base
1 -2.0 -8.0
2 -1.8 -5.832
3 -1.5 -3.375
4 -1.4 -2.744
5 -1.0 -1.0
6 -0.8 -0.512
7 -0.5 -0.125
8 -0.4 -0.064
9 0 0
10 0.4 0.064
11 0.5 0.125
12 0.8 0.512
13 1.0 1.0
14 1.4 2.744
15 1.5 3.375
16 1.8 5.832
17 2.0 8.0
Untitled function2.dat Ln 16 Col 6
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. 9.1.7.

ANFIS,

$$y = x^3.$$



. 9.1.8.

$$y = x^3$$

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(. 9.1.1).

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26.03. N	39	
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2.04. N	45	
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 book1/index.asp.htm](http://www.nsu.ru/matlab/MatLab_RU/fuzzylogic/book1/index.asp.htm)
5. . . .
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6. . . . / . ,
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7. . . . / . -
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9. . . . MATLAB /
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2. [].- : ,2006. – 304 . /
3. / . . // . – 2009. – 4. – T. 2. – . 217–220.
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4. : , / . . . – : – , 1999. – 320 .
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6. MATLAB / . . . – : – , 2007. – 288 .

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