³0 4B # U•2095-4980U‹2023 JUC2-0189-06

# & º UTADIS " +°D¼ 0#¼ -5í0u3Ó P Æ

B¡ | U• L"£ U•4ƒ Iµ

( Y )7V/¦ FKò ˜ $ L# z*a | ¬ [-@/¢ I U•!‹7û JM 214063

„ >- U•D¼ 0#¼ -5í0u3Ó P Æ [*a | % ÃM² +°Fù>--@/¢A*MÄU•I´ %(Ü 5+° 9Bß U• U*T F ò E 21§+° t*T Ì S P W 6 5 " % *'4U• &/÷ ² , .ùD¼ 0#¼ -5í0u3Ó P Æ å" 3ÿ È=" : U• U*T 6 5 " % *4) K ò-š 4)2 \ P ÆD¼ 0#¼ -5í0u3Ó U•6) K •(Ü ß0,51 { © › U•E 6) 1ê-š \ \@ÍD¼ 0#¼ -5í/7 Ò A å" T S6) ¸ Ê*T S åLŽ £ 5 D ë U{ ,.ù Ü+° P ÆE@ °

ŸJZ@ÙU•D¼ 0#¼ -5í0u3Ó P ÆŽF ò E 21§ Užt*T Ì S P W" Užf " ' Œ UžF Š S ß0,

Y * 21§ # U•TN914.42 ³(Z 3 -- U•A doiU•10.11805/TKYDA.2020608

## & N J U U F S U I S F B U M F W F M F W B M V B U J P O

; ) " 0 5 PUG H) " / ( ) B J U• V 6 0 % J O H

- F J I V B & M F D U S P O J D 5UF 'D7I*GP 8MVPY-HJZ +*JOBTOU-HJTUVS LUFO B

" C T U S B C T U F D F N J U U F S U I S F B U M F W F M F W B M V B U J P O J T B O J N Q P S U B O U 5 P E F B M X J U I U I F E J T B E W B O U B H F T P G U I F D V S S F O U I N F 6 5 I J P M E J T U S P S F " E E J U J W F T % * 46 5 S' ¾ N* 4 O B U I P X E T J D I J T B N F U I P E P G N V M U J J D T S J U F S J B D J O U S P E*V U D F J E T J O E J D B U F E U I B U F S 5 B % P 4 O B D B M F Q B S O P E V B D D P V G S B N I F U F U W B M V B U I S F B U M F W F M U I B U S F G M F D U I F Q S F G E S F O D F P G E F D J T J P O N B L E S T E F H S F V 6 5 " % * 4 I B T B E W B O U B H E S B Q Q Q N F S B B O E S U B X O B X B Z B O E P F G G F D U J W F F W B M V B U F U I F F N J U U F S U I S F B U M F W F M

, F Z X F U S E N T J U U F S U I S F B U Už M F W U F M D S F J W E N J V B 6 5 M H J U F G J " E E E U J U F J O V E T % * 4 D S J N J N B D I J O F MŽ N B V S M O U J J Q H M F B U U S J C V U F E F D J T J P O N B L J O H

D¼ 0#¼ -5í0u3Ó P Æ [*a | % ÃM² +°Fù>--@/¢A*MÄ w , T*a | % Ã YL,>-@ò W D f(Û ¯ Y P -5íD¼ 0 #¼U• ¢ e š -5í0u3Ó 2Fy ž œBp#¼ , y U•D¼ 0#¼ -5í0u3Ó P Æ 2 f & º f " ' Œ +° å" [1 3] ¸ & º F Š S ß0, +° å" [4 8] & º f " ' Œ +° å" [ 2 û V -5í0u3Ó>ò f , V1§ U• ¢ U*T ß0,51 ü Ç +°@Ù3ï œ š@Ù3ï 21§ "E =x 21§ ¢ D%å [ ò-š SD¯P U• g>î 2L • ùD¯ = r*] º 9 8 -5í0u3Ó % À+°1§ ÊKq 6 Ž < ² , V*] ß0,51 { © › ß Æ+° { » Ÿ2' U•58A ' Œ å" T@Ù3ï 21§ " " ¢!Í 5 U*TE .ù1§ wK +° { » Ÿ2' U• • V6) ú e X 6? ßD¼ 0#¼ -5í0u3Ó P ÆK MÄ & º F Š S ß0,+° å" U*T t*T ) œ0u £ g*g ¸ ü ß0,51 { © › ¢ D%å [5/;} ² 9 8 -5í0u3Ó wK +° { » Ÿ2' 0R 4K MÄ5ø U• rL,>- ß0,51, Ñ ü Ç { © › U• g>î SD¯ f •L,E , '-@/¢ f ò-š Î>î 5 t+°D¼ 0#¼ -5í0u3Ó P Æ å"

Dý KU• ) B,$ Ÿ '51 ü & ² F ò E 21§ (Multicriteria Classification UTMC))2@æ[9,10] F ò E 21§ [ ,.ù3ÿ 4 ² F Š S ß0,+° 21§ å" U• T? ß W 5 { © ›+°'¥ ¶ 21§K MÄ F ò E 21§ 9L,>- ß0,51, Ñ ü Ç { © › U• 58 [EFDó ß0,51 ü Ç £ 5 { © ›+°@Ù3ï œ š U• ú587 Ô \@Í ß0,51+° { © › U• • ß0,51 g>î • ù = ,7 & U• F ò E 21§ 8 " £ 5 f " ' Œ ¸ F Š S ß0, å" +° D%å U• ¢ Q=' ² 2.ù å" +° 9Bß U• 0R 4D¼ 0#¼ -5í0u3Ó P ÆK MÄ5øU• 5 G < f? ßA K MÄ+° ÜE@ °

X ³5/;} 2 F ò E 21§+° ¤ · å" ÿ ÿ t*T Ì S P W (UTADIS)" [10]*T ºD¼ 0#¼ -5í0u3Ó P ÆU• ¢EFDó +,K A : ¢ 5 t S

b/k K U•2020-11-09Už K U•2020-12-18

## 1 D¼ 0#¼ -5í0u3Ó P ÆK MÄ

D¼ 0#¼ -5í0u3Ó P ÆK MÄ+° œ ’ ûE fU•@ê 5$M$.ù -5í0u3Ó U•(Ü"w ÃD¼ 0#¼+°'¥ - î œ =Fû f $X$U•>- & º $X$ P ÙD¼ 0#¼ Š º V -5í0u3Ó D¼ 0#¼ -5í0u3Ó P Æ ÊKq 6 [ , V 21§K MÄU• Fó*T [ - =Fû f (Support Vector MachineU•SVM)0u L4 21§ å" !n? rD¼ 0#¼ -5í0u3Ó P Æ £ 5 L4 21§K MÄ 9 £ 3+° 2 V'¥%åU•a) ß0,51 % º 9 8 -5í0u3Ó 5 9 8+°Fù>ò/7 Ò U• • e š ß0,51 { ©-š Æ1§ wK +° { » Ÿ2' Užb) û V'¥ - £ 5 { © › U• 6) K ß ÆE .ù1§ wK +° { » Ÿ2' U• ®U•D©M½B¶US -5í0u3ÓB¶P $ BßE 2 V'¥%å+° 21§K MÄ=×/ f F ò E 21§K MÄ • U• 2D¼ 0#¼ -5í0u3Ó P Æ>ò f , V F ò E 21§K MÄ U• ¢ À*T F ò E 21§ å" !n?

## 2 UTADIS" ÷3ù

T UTADIS" Y U•'¥ -=×/ f ò E UTADIS U*T t*T ) œ=•Fû ß0,51 % û V1§+°Fù>ò/7 Ò U• ú58 g*g1§ w K +° { » Ÿ2' @ê 5$P$ V K BÏ+° ò E $c_1, c_2, \cdots, c_P$U•$x_i$ f ò E $c_i$ +° h U•'¥ - î œ =Fû f $\boldsymbol{X}=[x_1, x_2, \cdots, x_P]$U• E t *T ) œFó*T3ë S Ì o+° Ž ; U•$V(\boldsymbol{X})=\sum_{i=1}^{P} p_i v_i(x_i)$U• ¢ Y $p_i$ fLŠBK d œU•=•Fû ò E $c_i$ +°Fù>- SU•$\sum_{i=1}^{P} p_i = 1$Užv$_i(x_i)$ f ò E $c_i$ +°DåKq t*T ) œ U•$ Bßv$_i(\cdot)$ f •A/ ) œ U• @$v_i(x_{i'})=0$ ö $v_i(x_i^*)=1$U• ¢ Y $x_{i'}$ ¸ $x_i^*$ 2 W f ò E $c_i$ Y , 9=× { © ¸ , =× { © +° h @ê 5$M$ V M° t 3 Æ +° 1§ $G_i (i=1,2,\cdots,M)$ s @ê$i<j$U• E $G_i$ ! $G_j$ =× { © U• Ò Ÿ $G_1 > G_2 > \cdots > G_M$ @ê Ê œ$u_1 > u_2 > \cdots > u_{M-1}$U• E UTADIS" 4 & 21§ ® 7 U•

$$\begin{cases} V(\boldsymbol{X}) \geqslant u_1 \Rightarrow \boldsymbol{X} \in G_1 \\ u_m \leqslant V(\boldsymbol{X}) < u_{m-1} \Rightarrow \boldsymbol{X} \in G_m (m=2,\cdots,M-1) \\ V(\boldsymbol{X}) < u_{M-1} \Rightarrow \boldsymbol{X} \in G_M \end{cases} \tag{1}$$

UTADIS" U*T@Ù3ï œ šKò$\{\boldsymbol{X}_1, \boldsymbol{X}_2, \cdots, \boldsymbol{X}_N\}$-š Æ t*T ) œ $V(\boldsymbol{X})$ ¸ t*TK K| $\{u_k, k=1,2,\cdots,M-1\}$ %$j=1,2,\cdots,N$U• Æ uU•

$$\begin{cases} \sigma_j^+ = \begin{cases} \max\{0, u_k - V(\boldsymbol{X}_j)\}, & \boldsymbol{X}_j \in G_k, k \in \{1,2,\cdots,M-1\} \\ 0, & \boldsymbol{X}_j \in G_M \end{cases} \\ \sigma_j^- = \begin{cases} \max\{0, V(\boldsymbol{X}_j) - u_{k-1}\}, & \boldsymbol{X}_j \in G_k, k \in \{2,3,\cdots,M\} \\ 0 & \boldsymbol{X}_j \in G_1 \end{cases} \end{cases} \tag{2}$$

; Y U•$\sigma_j^+$ f 2 $\boldsymbol{X}_j$ 2 \ •-š+°1§ " U•$V(\boldsymbol{X}_j)$ L,>- Ê Ì+° h Užv$_j^-$ f 2 $\boldsymbol{X}_j$ 2 \ •-š+°1§ " U•$V(\boldsymbol{X}_j)$ L,>- û ;+° h $\sigma_j^+$ ¸ $\sigma_j^-$ s ÒFû 2 $\boldsymbol{X}_j$ 2JE+°/7 Ò E5 t*T ) œ $V(\boldsymbol{X})$ ö t*TK K| $\{u_k, k=1,2,\cdots,M-1\}$U• « $\sum_{k=1}^{M}\left[\frac{1}{m_k}\sum_{\substack{1\leqslant j\leqslant N \\ \boldsymbol{X}_j \in G_k}}\left(\sigma_j^+ + \sigma_j^-\right)\right]$Dê \ , ; U• ¢ Y $m_k$ f Š º1§ $G_k$ +° $\boldsymbol{X}_j$ +° V œ *] ; (2) - U•$\sigma_j^+$ ¸ $\sigma_j^-$ £ 5 ® 7 SBT U•

$$V(\boldsymbol{X}_j)+\sigma_j^+ \geqslant u_1 (\boldsymbol{X}_j \in G_1), V(\boldsymbol{X}_j)-\sigma_j^- < u_{M-1} (\boldsymbol{X}_j \in G_M), V(\boldsymbol{X}_j)+\sigma_j^+ \geqslant u_k, V(\boldsymbol{X}_j)-\sigma_j^- < u_{k-1} (\boldsymbol{X}_j \in G_k, k \in \{2,\cdots,M-1\}) \tag{3}$$

*] • &/÷ ¢!n? D BK MÄ U•8ã Ã t*T ) œ ö t*TK K|+° \@Í U•? ß F ò E 21§K MÄ

T À*T UTADIS" E =xD¼ 0#¼ -5í0u3Ó P Æ "U•L,>- e š,$ Ÿ5ø › U•E5 4E.+° t*T ) œ Ž ; U• % t*T ) œ 4)2 î œ B U• ¢ &/÷ ? +° D BK MÄ U•&b :!n?

## 3 UTADIS" TD¼ 0#¼ -5í0u3Ó P Æ Y+° À*TK MÄ

### 3.1 t*T ) œ î œ B

%D¼ 0#¼ -5í/7 Ò 5Fù>- • ù+° î œ g>- 1 D©M½ 65 é 65 ÞFù 9M½(Pulse Repetition FrequencyPRF) œ š(³ ( • y "K ±D¼ 0#¼+° Ÿ s @ë M œ )0u • U• 2D©M½(GHz) 65 é $c_2$(µs) PRF$c_3$(kHz) ¸ œ š(³ $c_4$(s$^{-1}$) ^ f UTADIS" +° ò E [8] *] º ' ; ) œF)6)*T 2's3ë S ) œ ' ;1ê-š ÒEhDý U• • 2 0 ò EDåKq t*T ) œ v$_i(\cdot)(i=1,2,\cdots,4)$ & M f 2's3ë S ) œ

% ºD©M½ ò E•*] º H2N@’ >L#DêEF d f S,C" á U• b (L#DêEF d f X" á U• •D©M½B¶ SU• E -5í0u3ÓB¶

P U•D©M½DåKq t*T ) œ $v_1(\cdot)$ À f •A/ Ê ) œ e š3ûO¸ U• •D©M½ S º10 GHz "D©M½+° B % -5í0u3Ó • ù 9 S U• •@Ð fD©M½ ò E+° h8/ f $[0, x_{1,\max}]$U• $x_{1,\max} = 10$ D©M½ ò E h $x_1$ :D¼ 0#¼D©M½ Ÿ2' f $x_1 = \min(f, 10)$

% º65 é ò E U•@Ð f 65 ±A/ b+°65 é f " é U• 565 ±A/ b+°65 é f,Ø " R é+° > œ % º -5íL#Dê U• ; 65 é £ 5P C .ç 2DÔ Ç U•EF d@Ð f 5D¯P +° -5í0u3ÓU• •65 éDåKq t*T ) œ $v_2(\cdot)$ À f •A/ û ) œ e š3ûO¸ U• •65 é S º 200 µs " U•65 é+° B % -5í0u3Ó • ù 9 S U• •@Ð f65 é ò E+° h8/ f $[0, x_{2,\max}]$U• $x_{2,\max} = 200$ 65 é ò E h $x_2$ :D¼ 0#¼65 é$T$+° Ÿ2' f $x_2 = \min(T, 200)$

% º PRF ò E U• ,7X@Ð fP PRF £ 5D¯P -5í0u3Ó U• • PRFDåKq t*T ) œ $v_3(\cdot)$ À f •A/ Ê ) œ e š3û O¸U• • PRF S º 30 kHz " U•PRF+° B % -5í0u3Ó • ù 9 S U• •@Ð f PRF ò E+° h8/ f $[0, x_{3,\max}]$U• $x_{3,\max} =$ 30 PRF ò E h $x_3$ :D¼ 0#¼PRF+° Ÿ2' f $x_3 = \min(PRF, 30)$

% º œ š(³ ò E U• •L#Dê 0 º H2N'â - " U• œ š(³D¯ ; U• -5í/7 ÒD¯ z Už•L#Dê 0 ºC CV'â - " U• œ š(³ D¯ SU• -5í/7 ÒD¯P • œ š(³B¶ S U• E -5í0u3ÓB¶P U• œ š(³DåKq t*T ) œ $v_4(\cdot)$ À f •A/ Ê ) œ • œ š (³ S º 5 M/s " U• œ š(³+° B % -5í0u3Ó • ù 9 S U• •@Ð f œ š(³ ò E+° h8/ f $[0, x_{4,\max}]$U• $x_{4,\max} = 5$ œ š(³ ò E h $x_4$ :D¼ 0#¼ œ š(³ $r$ +° Ÿ2' f $x_4 = \min(r, 5)$

& º 6E 2 ¼ U•NÂ t5/;}D©M½ PRF œ š(³ ò E+° •A/ ÊDåKq t*T ) œ î œ B å" 5/;} ) œ $\tilde{v}_i(\cdot) = p_i v_i(\cdot)$U• 4 Æ $x_{i^*} = x_i^{(1)} \leqslant x_i^{(2)} \leqslant \cdots \leqslant x_i^{(a_i)} = x_i^*$U• ¢ Y $x_i^{(1)} = 0$U• $x_i^{(a_i)} = x_{i,\max}$ @ê $\tilde{v}_i(x_i^{(h)}) = v_i^{(h)}$, ¢ Y $0 = v_i^{(1)} \leqslant v_i^{(2)} \leqslant \cdots \leqslant v_i^{(a_i)}$U• E $\tilde{v}_i(x_i) = v_i^{(h)} + \frac{x_i - x_i^{(h)}}{x_i^{(h+1)} - x_i^{(h)}}(v_i^{(h+1)} - v_i^{(h)}), x_i \in [x_i^{(h)}, x_i^{(h+1)}]$ $w_{i,h} = v_i^{(h+1)} - v_i^{(h)} (h = 1, 2, \cdots, a_i - 1)$U• E $w_{i,h} \geqslant 0$ ö

$$\tilde{v}_i(x_i) = \sum_{l=1}^{h-1} w_{i,l} + \frac{x_i - x_i^{(h)}}{x_i^{(h+1)} - x_i^{(h)}} w_{i,h}, x_i \in [x_i^{(h)}, x_i^{(h+1)}] \tag{4}$$

2 $w_{i,h} (h = 1, 2, \cdots, a_i - 1)$ ^ fDåKq t*T ) œ $\tilde{v}_i(x_i)$ +° î œ $x_i^{(h)} (h = 1, 2, \cdots, a_i)$ f BF î œM° t4 Æ U• e š3ûO¸ U• % ºD©M½ ò ŒU•E5 $a_1 = 4, x_1^{(1)} = 0, x_1^{(2)} = 4, x_1^{(3)} = 8, x_1^{(4)} = 10$Už % º PRF ò E U•E5 $a_3 = 4, x_3^{(1)} = 0, x_3^{(2)} = 1, x_3^{(3)} = 3, x_3^{(4)} = 30$Už % º œ š(³ ò E U•E5 $a_4 = 4, x_4^{(1)} = 0, x_4^{(2)} = 0.5, x_4^{(3)} = 1, x_4^{(4)} = 5$

KG •A/ ÊDåKq t*T ) œ î œ B IC U•5/;}65 é ò E •A/ ûDåKq t*T ) œ î œ B å" 5/;} ) œ $\tilde{v}_i(h = 1, 2, \cdots, a_i - 1) = p_i v_i(\cdot)$U•4 Æ $x_{i^*} = x_i^{(1)} \geqslant x_i^{(2)} \geqslant \cdots \geqslant x_i^{(a_i)} = x_i^*$U• ¢ Y $x_i^{(1)} = x_{i,\max}$, $x_i^{(a_i)} = 0$U•@ê $\tilde{v}_i(x_i^{(h)}) = v_i^{(h)}$U• ¢ Y $0 = v_i^{(1)} \leqslant v_i^{(2)} \leqslant \cdots \leqslant v_i^{(a_i)}$U• E $\tilde{v}_i(x_i) = v_i^{(h)} + \frac{x_i - x_i^{(h)}}{x_i^{(h+1)} - x_i^{(h)}}(v_i^{(h+1)} - v_i^{(h)}), x_i \in [x_i^{(h+1)}, x_i^{(h)}]$ $w_{i,h} = v_i^{(h+1)} - v_i^{(h)} (h = 1, 2, \cdots, a_i - 1)$U• E $w_{i,h} \geqslant 0$ ö

$$\tilde{v}_i(x_i) = \sum_{l=1}^{h-1} w_{i,l} + \frac{x_i - x_i^{(h)}}{x_i^{(h+1)} - x_i^{(h)}} w_{i,h}, x_i \in [x_i^{(h+1)}, x_i^{(h)}] \tag{5}$$

2 $w_{i,h} (h = 1, 2, \cdots, a_i - 1)$ ^ fDåKq t*T ) œ $\tilde{v}_i(x_i)$ +° î œ $x_i^{(h)} (h = 1, 2, \cdots, a_i)$ f BF î œM° t4 Æ U• e š3ûO¸ U• % º65 é ò E U•E5 $a_2 = 4, x_2^{(4)} = 0, x_2^{(3)} = 0.5, x_2^{(2)} = 10, x_2^{(1)} = 200$

2 ; (4) ¸ ; (5) Å <4 ,+° Ž ; U• Ã $V(\boldsymbol{X}_j) = \sum_{i=1}^{P} \left( \sum_{l=1}^{r_{ji}-1} w_{i,l} + \frac{x_{ji} - x_i^{(r_{ji})}}{x_i^{(r_{ji}+1)} - x_i^{(r_{ji})}} w_{i,r_{ji}} \right)$U• ¢ Y $r_{ji}$ f $\boldsymbol{X}_j$ +°0X$i$ V ò E h $x_{ji}$U• l Š fK f $\left[ \min(x_i^{(r_{ji})}, x_i^{(r_{ji}+1)}), \max(x_i^{(r_{ji})}, x_i^{(r_{ji}+1)}) \right]$ t*T ) œ $V(\cdot)$ +° î œ $w_{ih} (h = 1, 2, \cdots, a_i - 1; i = 1, 2, \cdots, P)$, $x_i^{(h)} (h = 1, 2, \cdots, a_i;$ $i = 1, 2, \cdots, P)$ f BF î œM° t4 Æ

3.2 &/÷ ? +° D BK MÄ

*] 6 ,7® - U• t*T ) œ $V(\cdot)$ +° î œ $w_{i,h}$ $ Bß $\sum_{i=1}^{P} \sum_{l=1}^{a_i - 1} w_{i,l} = 1$ ö $w_{i,h} \geqslant 0$ • U•3ÿ 43Ò ‹ ; (3)U• &/÷ ® 7 D BK MÄU•

$$\begin{cases} \min \sum_{k=1}^{M}\left[\frac{1}{m_k}\sum_{\substack{1\leqslant j\leqslant N\\ \boldsymbol{X}_j\in G_k}}\left(\sigma_j^{+}+\sigma_j^{-}\right)\right] \\ s.t.\ \sum_{i=1}^{P}\left(\sum_{l=1}^{r_{ji}-1}w_{i,l}+\frac{x_{ji}-x_i^{(r_{ji})}}{x_i^{(r_{ji}+1)}-x_i^{(r_{ji})}}w_{i,r_{ji}}\right)+\sigma_j^{+}-u_1\geqslant\delta_1(\boldsymbol{X}_j\in G_1),\sum_{i=1}^{P}\left(\sum_{l=1}^{r_{ji}-1}w_{i,l}+\frac{x_{ji}-x_i^{(r_{ji})}}{x_i^{(r_{ji}+1)}-x_i^{(r_{ji})}}w_{i,r_{ji}}\right)-\sigma_j^{-}-u_{M-1}<-\delta_2(\boldsymbol{X}_j\in G_M) \\ \sum_{i=1}^{P}\left(\sum_{l=1}^{r_{ji}-1}w_{i,l}+\frac{x_{ji}-x_i^{(r_{ji})}}{x_i^{(r_{ji}+1)}-x_i^{(r_{ji})}}w_{i,r_{ji}}\right)+\sigma_j^{+}-u_k\geqslant\delta_1,\sum_{i=1}^{P}\left(\sum_{l=1}^{r_{ji}-1}w_{i,l}+\frac{x_{ji}-x_i^{(r_{ji})}}{x_i^{(r_{ji}+1)}-x_i^{(r_{ji})}}w_{i,r_{ji}}\right)-\sigma_j^{-}-u_{k-1}<-\delta_2\left(\boldsymbol{X}_j\in G_k,k\in\{2,\cdots,M-1\}\right) \\ \sigma_j^{+}\geqslant 0,\sigma_j^{-}\geqslant 0(j=1,2,\cdots,N),u_k-u_{k+1}\geqslant s(k=1,2,\cdots,M-2),\sum_{i=1}^{P}\sum_{l=1}^{a_i-1}w_{i,l}=1,w_{ih}\geqslant 0(h=1,2,\cdots,a_i-1,i=1,2,\cdots,P) \end{cases} \tag{6}$$

; Y U•$w_{i,h},\sigma_j^{+},\sigma_j^{-},u_k$ f D B Fû Už$\delta_1,\delta_2,s,a_i(i=1,2,\cdots,P),x_i^{(h)}$ f M · BF î œ Už$a_i$ f • œ Už$\delta_1>0,\delta_2>0,s>0,s>\delta_1+\delta_2,\delta_1+\delta_2+(M-2)s<1$U•$\delta_1$ ¸ $\delta_2$EF d f q 2 ;+° • œ

; (6) f3ë S D BK MÄU• • Fó*T •3Û Ž" 0u œ h å" !n? , D? U•8ã Ã t*T ) œ $V(\cdot)$+° î œ $w_{i,h}$ ö t*T K K| $\{u_k\}$+° , D \@Í U•? ßD¼ 0#¼ -5í0u3Ó P ÆK MÄ

T!n? D BK MÄ ; (6) " U• & º g>î6) K å ? P ÙD¼ 0#¼ [ Š ºP -5íE [ z -5í U• • t@Ð f 5 2 V -5í0u3ÓU• Ÿ $M=2$U• ¢@Ð f1§$G_1$ =”P -5í U•$G_2$ =” z -5í T!n Ã t*T ) œ $V(\cdot)$ : U• e š ÊKqL,!n % t*T ) œ h fK E , ‘ > 2 U• Ó*K F+° -5í0u3Ó T /7 À*T Y U•!n? D BK MÄ8ã Ã t*T ) œ î œ ö t*TK K| , D \@Í+°Dó/7 .ç3ëE =x U• • T3ëE =xD¼ 0#¼ -5í0u3Ó P Æ "U• L, e šD¼ 0#¼'¥ - î œ@Í0Ã ¢ t*T ) œ U• ¢ 2 t*T ) œ : t*TK K|! D¯ U• ] 8ã Ã ¢ -5í0u3Ó • å" ? /7 Ê(Ü U•6) K$ Bß Ê " S>-!n

## 4 S6) 2 ¼

### 4.1 @Í0Ã j ·

& º - ¤ ·D¼ 0#¼ œ š Ó*KD¼ 0#¼ œ šKòU• ¢ 2A œ šKò ^ f UTADIS +°@Ù3ï œ šKò $\delta_1=\delta_2=0.01$U•!n ? 3ë S D BK MÄ ; (6)U• Ã \ 0 ò E+°DåKq t*T ) œ î œ ö oFù ®=” 1 l.f U• t*TK K| $u_1=0.6754$ s@ê ^ DN f E™Es ¾4 V -5íD¼ 0#¼U•=” 2[8]4 & ²E ÇD¼ 0#¼+°'¥ - î œ h t*T ) œ \@Í ¸ -5í0u3Ó \@Í 7LŽ 2 ¼3ÿ È+° 4)2 S D¼ 0#¼2,4 +° œ š(³ s 9 ; º 1 M/sU• Š ºC CV'â - Už58D¼ 0#¼4,3 +° œ š(³ s 9 S º 0.5 M/sU• Š º H2N'â - U• •D¼ 0#¼ 2,4 +° t*T ) œ \@Í hD¯ S U• -5í0u3ÓP • B U•D¼ 0#¼4 +°D©M½ ¸PRF s S ºD¼ 0#¼2U• •D¼ 0#¼ 4 +° t*T ) œ \@Í h S ºD¼ 0#¼ 2 ,7 & U• U*T UTADIS " 6) KD¯ 4)2 \4 &D¼ 0#¼ -5í0u3Ó

### 4.2 BF î œ % S6)+° • ù

=” 1 ,$ Ÿ î œ!n? 3ÿ È

Table1 Results of relevant parameters

| | $w_{i,h}(h=1)$ | $w_{i,h}(h=2)$ | $w_{i,h}(h=3)$ | $p_i$ |
|---|---|---|---|---|
| $i$=1 | 0.3357 | 0.3377 | 0.3266 | 0.1168 |
| $i$=2 | 0.3794 | 0.3987 | 0.2219 | 0.1180 |
| $i$=3 | 0.2797 | 0.3176 | 0.4027 | 0.1327 |
| $i$=4 | 0.1325 | 0.7831 | 0.0844 | 0.6326 |

=” 2 D¼ 0#¼'¥ - î œ › ö -5í0u3Ó P Æ

Table2 Emitters information and threat level evaluation

| emitters | $f$/GHz | pulse width/μs | PRF/kHz | data rate/($s^{-1}$) | utility function value | evaluation |
|---|---|---|---|---|---|---|
| 1 | 10.0 | 0.500 | 3.6 | 0.25 | 0.3309 | $G_2$ |
| 2 | 5.5 | 0.250 | 4.0 | 1.00 | 0.8193 | $G_1$ |
| 3 | 9.5 | 0.300 | 3.0 | 0.50 | 0.3726 | $G_2$ |
| 4 | 9.8 | 0.284 | 11.0 | 5.00 | 0.9437 | $G_1$ |

*]3ë S D BK MÄ ; (6) ,7 & U• U*T UTADIS " E =xD¼ 0#¼ -5í0u3Ó P Æ+° S6) g>- : BF î œ $x_i^{(h)}(h=1,2,\cdots,a_i,i=1,2,\cdots,4)$ 5 Ÿ 7LŽEFDó +,KA : BF î œ $x_i^{(h)}$+°E5 % S6)+° • ù ^ f %&“ U•Fó*T s , > 2 å" -š Æ BF î œ $x_i^{(h)}$ * 1 2 W4 &Fó*T3ûO¸" ¸ s , > 2" " U•D¼ 0#¼+° t*T ) œ \@Í t*TK K| öD¼ 0#¼ Ê Kq -5í0u3Ó -5í0u3Ó h f 1U•=”.fP -5í Už h f 0U•=”.f z -5í ® È \@Í+° t*T ) œB¶ ÑDý ÊKq -5í0u

3ÓU• E t*T ) œ+° \@Í ]B¶ © *] * 1 ,7 & U•Fó*T s , > 2" % S6)+° • ù 9 S • U• @Ð f BF î œ $x_i^{(h)}$ %3ÿ È • ùD¯ ;

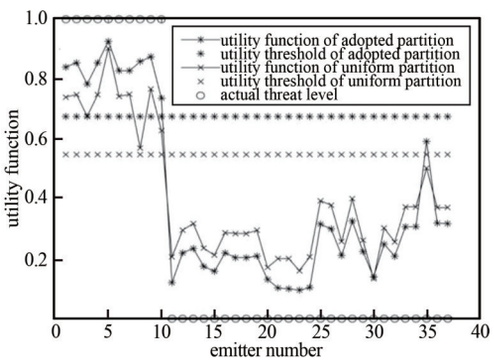


Fig.1 Effects of external parameters
* 1 BF Fû+° • ù

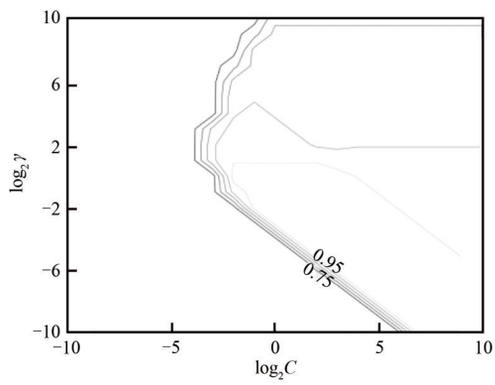


Fig.2 Contour map for correct prediction rate of threat levels using cross-validation
* 2 Ð õO¸@í -5í0u3Ó P Æ •-š(³0uP 3ë *

4.3 S6)! D¯

2 UTADIS" : L4 f " ' Œ å" E =x S6)! D¯ E5 SVM ^ f %! U• [ f5/;} \ 5 2 V1§+° 21§K MÄ ö SVM : M « eFy U•E. *T º*a | % Ã À*T5ø › SVM +° d ) œFó*TP Û d $K(x,y)=\exp(-\gamma\|x-y\|_2^2)$U• U*T Ð õO¸@í*… ," 8ã Ã SVM +° • E B î œ $C$ öP Û d î œ $\gamma$ +° , D3ð 4 f $C=0.25,\gamma=1$U• * 2 f Ð õ O¸@í A 3ò 3ÿ È * 3 f UTADIS ¸ SVM +° + ,K 3ÿ È U• ¢ Y UTADIS 4 & ² 0D¼ 0#¼+° t*T ) œ \@Í ¸ t*TK K| \@Í U•SVM 4 & ² 0D¼ 0#¼ -5í0u3ÓM°"w % º 2.ù å" U• û M ç µD¼ 0#¼ œ šKò+° , VD¼ 0#¼ Ž <+°@Ù3ï œ šKò&b : P Æ=× ç µ+°EÏ V D¼ 0#¼+° -5í0u3Ó ,7 & U•2.ù å" s 5D¯P • -š(³ % º UTADIS" U• 21§JEA +°D¼ 0#¼0+° t*T ) œ : t*TK K| ÑDý U• • i0Í 21§JEA U• ù6) Ã \D¯ ò-š+° t*T ) œ \@Í % º SVMU• 21§JEA +°D¼ 0#¼+° t*T ) œ \@Í ÑDý º 1U• • SVM 21§3ÿ È : t*T ) œ \@Í3ÿ È 9 ,7 U•=" : SVM 21§!Í 5 •(Ü ß0,51 { © › • UTADIS £ 5 D ë E ,7 & U•UTADIS" EFDó4 & t*T ) œ \@Í U•6) K ü Ç 1ê3ò+° -5í/7 Ò g*g U• +ö º :4 À*T

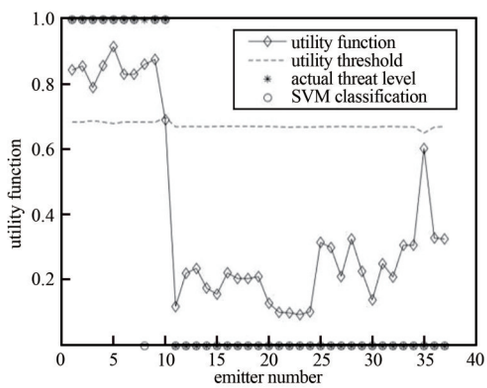


Fig.3 Comparison of UTADIS and SVM
* 3 UTADIS : SVM å" %!

## 5 3ÿ@æ

X ³ 2 F ò E 21§ å" UTADIS" À*T ºD¼ 0#¼ -5í0u3Ó P Æ +,K=" : U•UTADIS" 9 ñ6) KD¯ ò-š \4 &D¼ 0#¼ -5í0u3Ó P Æ3ÿ È•E 6) K4 & ò-š+° t*T ) œ \@Í U• ü Ç 1ê-š+°D¼ 0#¼ -5í/7 Ò@ð \ U•,$! ¢ å" T S6) ¸ Ê*T S åLŽ £ 5 D ë U*T UTADIS Ê(Ü7 E. À 7 ' Œ+°D¼ 0#¼ -5í0u3Ó P ÆU•E. 4 V ' ¦ 6)@Ð- *a | % Ã ý •B· ë U• [D¼ 0#¼ -5í0u3Ó P Æ+° ,.ù 5 t ÜE@ °

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[ ] Á6 ó ,.ù & º eE [ - =Fû f+°, 3 -5í \@Í å" [ ┼ 7\7e*a | /7 + * / ( 4 I F O H 'Z P U B S H F U
U I S F B U B T T F T T N F O U B Q Q S P B D I C B T F E [ ┼ P O 4 I J N Q Q & M W D E S T P \ O Q J Q P & S O J H W F D E U S P J S O N B D
E P J KJ T T O
[ ] —5 8/ '$ & º v+ý,• ' Œ+°7\7s, 3 -5í P Ù-@/¢ [ ┼ 2'4 +,K ¬ [ 8 & * 9 J B"O H V F N B O
3 F T F B S D I P O U I F U B S H F U F W T B W Q V F B S J W J E T D [ ┼ E G M Z K T B U S F O U J Q Q H N V C M B E E E P O O 5 F E N O
E P J KD O D D D