# 2020 Machine Learning

# **Second Assignment**

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# 1 åĘŹåIJĺåĽŊéİć

2019åźť12æIJĹèţůåijĂåğŃåIJĺæĹŚåŻ¡æźŰåŇŮæŋęæśĽåIJřåŇžæţĄèąŇçŽĎæŰřåĘăèĆžçĆŐæŸŕçżğ2003åźťåŘŐçŽĎä åőČçŽĎäijăæ§ŞåŁŻåŊĄåĹĘåijžåďğ. ä¡ĘçżŔè£ĞæĹŚåŻ¡æŤ£åžIJäżěåŔŁäžžæřŚäÿŊæČIJäżčäżůçŽĎåŁłåŁŻåĕŃæŰŮ, æŋďæňąçŮĚæŕŠåIJĺâĂIJäžžæřŚæĹŸäžĽâĂİçŽĎæśłæťŃåďǧæţůäźŃäÿŋåůšçżŔåĹİæŸ¿éćŞåŁ£. åęĆ**åŻ¿ 1** [1], åśŢçďžçŽĎæŸŕæĹŚåŻ¡åŘĎçIJĄäż¡çťŕèőąçąőèŕŁçŽĎäžžæŢř, éćIJèĽšèűŁæůśäżčèąĺçąőèŕŁäžžæŢřèűŁåďŽ. çżŔåŐĘäžĘäžďěĂŽçőąåĹűãĂĄåżžçńŃåŇżéŹćãĂĄåŔŁæŮűèřČåŁĺėţĎæžŘåŠŇäžžåŁŻçŋĽæŐłæŰ¡åŘŐïijŇè£ŚäžŻåďĨælěï



åŻ; 1: åĚĺåŻ¡çŰńæČĚåIJřåŻ¿.

èĞşâřŚæŋďæŮűæŋďãĹż(2020.2.29), æĹŚåŻ¡çŽĎæČĚåĘţåůšçżŔæŸŐ柿åě¡è¡ň, éŹďĕĞŊçĄ¿åŇžæźŰåŇŮäżĕåďŰåŘÌçńŹåIJĺè£ŹæňąçĄ¿éŽ¿åŊşåřĘè£ĞåŐżçŽĎæŮűåĹż, æĹŚäżňèŕŢçİĂäżŐåŘĎæŰźéİćçŽĎæŢřæŊőäźŃäÿŋåŕżæĽ¿äÿĂ䞯æIJæİĕäÿžåžŤåŕźäÿŃäÿĂæňąçśżäijijçĄ¿éŽ¿åĄŽåě¡åŊĄèűşçŽĎåĞĘåďĞ.

# 2 éŮőéćŸçąőåőŽ

åŕźäžŐâĂIJåŕźä¡ŢçĕŊéŮőéćŸè£ŻèąŇçăŤçľűâĂİè£ŹäÿĂéŮőéćŸ,æĹŚäżňæIJĽäžĘå¿ĹåďŽæČşæşŢ. éęŰåĚĹåĹŮåĞžæĺ

- èřčèĺĂæŢřæŊő;
- 2019-nCovçŮĚæŕŠåžŔåĹŮçŋĽ.
- èĆžçĆŐæĆčèĂĚèĆžéČĺCTæĽńæŔŔæŢřæŊő;
- $\bullet \ \, \ddot{a} \check{z} \check{z} \check{x} \check{f} \hat{x} \mathring{U} \check{e} \check{x} \check{L} \check{e} \check{x} IJ \mathring{L} \mathring{a} \check{E} \varsigma\varsigma \mathring{U} \acute{n} \check{x} \check{C} \check{E} \mathring{a} ; \\ \, \mathring{o} \mathring{a} N \check{Z} \grave{e} f \check{D} \grave{e} \check{o} \check{z} \check{x} \mathsf{T} \check{r} \check{x} N \check{o}; \\$
- $\bullet \ \, \text{\& Lipin$

åIJĺè£ŹäžŻæŢřæŊőéŻĘçŽĎå§žçąĂäÿŁ, æĹŚäżňèĂČèŹŚäžĘäżěäÿŃéŮőéćŸ:

Rank	Model	EM	F1
	Human Performance Stanford University (Rajpurkar & Jia et al. '18)	86.831	89.452
1 Jan 10, 2020	Retro-Reader on ALBERT (ensemble) Shanghai Jiao Tong University http://arxiv.org/abs/2001.09694	90.115	92.580
2 Nov 06, 2019	ALBERT + DAAF + Verifier (ensemble) PINGAN Omni-Sinitic	90.002	92.425
3 Sep 18, 2019	ALBERT (ensemble model) Google Research & TTIC https://arxiv.org/abs/1909.11942	89.731	92.215
4 Jan 23, 2020	albert+transform+verify (ensemble) qianxin	89.528	92.059
5 Dec 08, 2019	ALBERT+Entailment DA (ensemble) CloudWalk	88.761	91.745
6 [Feb 20, 2020]	Tuned ALBERT (ensemble model) Group Data & Analytics Cell   Aditya Birla Group) https://www.adityabirla.com/About/group-data- and-analytics	88.637	91.230
6 Jan 19, 2020	Retro-Reader on ALBERT (single model)  Shanghai Jiao Tong University  http://arxiv.org/abs/2001.09694	88.107	91.419

åŻ; 2: èŕŋèĺĂçŘĘèğčæĺąåđŃæŐŠåŘŊ.

#### åŕźäžŐçŰńæČĚæIJ§éŮťçŽĎèřčèĺĂè£ŻèąŇçŤĎåĹń.

åŕźäžŐæŋďéŮőéćŸçŽĎèğčåĘşæČşæşŢæŸŕå§žäžŐGoogleåijĂåŔŚçŽĎBERTæÍqåđŃ[2][3][4]åŕźäžŐèřčèÍĂæŰĞæIJňè åźűäÿŤä¡£çŤÍæIJžåŹÍåŋęäźăæĽ¿åĞžèřčèÍĂåĚůæIJĽçŽĎæŹőéĄŊ缟å¿Ą, äžŐèĂŇåŕźäžŐç¡ŚçżIJäÿŁæŹőéĄŊæţĄäijäçŽĎe 獜äžŐBERTæÍqåđŃæŸŕåijĂæžŘçŽĎ, åźűäÿŤGoogle[3]äź§åůšçżŔä¡£çŤÍåijžåďgçŽĎçőŮåŁŻåŕźåĚűè£ŻèąŇäžĘéŢ£æŮűéŮ åŻăæŋďä¡£çŤÍèĂĚåŔłéIJĂèęĄåŕźåĚűè£ŻèąŇå¿őèřČä¿£åŔŕäżěéŠĹåŕźçĽźåőŽçŽĎéŮőéćŸæĬėåžŤçŤÍ[5]. åęĆ**åŻ¿2** åśŢçďžçŽĎæŸŕèŕŋèÍĂçŘĘègčæÍqåđŃçŽĎæŐŠåŘŊ[6], åŔŕäżěçIJŃåĹřæŐŠåŘŊéĬäåĽŊçŽĎåďgåďŽéČ¡æŸŕå§žäžŐBERTæſä¡Ę獜äžŐæŮűéŮťçťgè£ń, æĹŚäżňåźűæšąæIJĽèűşåď§çŽĎçš¿åŁŻæĬěåŋęäźăæŋďçğŊæÍqåđŃçŽĎåŐ§çŘĘ, åŻăæŋďæŽĆäÿŊs

#### $\rat{arzaz} \Hat{O} \& \'at{C} \rat{C} \& \rat{E} \& \rat{C} \& \rat{C} \& \rat{E} \& \r$

獜äžŐçědçżŔç¡ŚçżIJäzěåŔŁTensorFlowçŽĎåŔŚæŸŐ, åŕźäžŐåŊŢäÿĂçśżåđŃçŽĎåŻ¿åČŔè£ŻèąŇèŕĘåĹńåźűåĹĘçśżźåęĆçĕdçżŔç¡ŚçżIJçŽĎåĚÿåđŃä¿ŃåŋŘ, åŕźäžŐæĽŃåĘŹæŢřåŋŮéŻĘ(MINST)ä¡£çŤĺçědçżŔç¡ŚçżIJæđĎåżžçŽĎæIJžåŹĺåŋęæŋčçąőçŐĞåůšçżŔåŔŕäżèè¿¿åĹřçŻÿå¡ŞéńŸ[7]. ä¡Ę獜äžŐåŔŕäżěæŤűéŻĘåĹřçŽĎèĆžéČĺCTåŻ¿æŢřéĞŔåźűäÿŊæŸŕåŊĄåèĂŇäÿŤä¡Ŋç¡őäź§äÿŊäÿĂèĞť, éIJĂèęĄèŁśèťźåďgéĞŔæŮűéŮťåŕźåŻ¿åČŔè£ŻèąŇåĽłåĹĞ. åŻäæŋďäź§äÿŊåŕźæŋďéŮőéćŸå

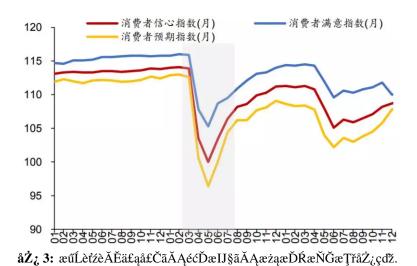
#### ä;£çŤĺæŰřåĘăèĆžçĆŐçŮĚæŕŠçŽĎDNAåžŔåĹŮåŕźäžŐåŔŕèČ;çŽĎæšżçŰŮèŊŕ缾è£ŻèąŇéćĎæţŃ.

çśzäijijçŽĎéŮőéćŸåůšçżŔæIJĽå¿ĹåďŽçăŤçľű, åęĆäÿŋåŻ¡ç§£äÿŽåď§åŋęéŹĹåĚťåŻć韧åŕźäžŐæIJłç§ěçŰ¿çŮĚçŽĎæÚ åŔŕäżĕéĂŽè£ĞåżžçńŃçŮĚæŕŠçŻÿäijijæĂğç¡ŚçżIJäżĕåŔŁçŮĚæŕŠäÿŐèŊŕ缾çŽĎåĚşèĄŤç¡ŚçżIJäżĕåŔŁèŊŕ缾äźŃéŮťçŽÌ ä¡ĘåŘŇæăů獜äžŐäÿŞäÿŽç§ěèŕĘçŽĎçijžäźŔäżěåŔŁæŮűéŮťåźűäÿŊåĚĚèčŢ, è£ŹäžŻç¡ŚçżIJçŽĎåżžçńŃéČ¡æŸ¿å¿Ůè¿ČäÿåŻăæŋďäÿŊåŕźæŋďéŮőéćŸåĄŽæůśåĚěçăŤçľű.

#### åŕźäžŐ矧çŰńåŘŐçŽĎçżŔæţŐæĄćåďŊéçåžęè£ŻèąŇéćĎæţŃ.

åIJÍåďgéČÍåĹĘäijĄäÿŽçżŔèŁĞéŢ£è¿¿äÿĂäÿłåďŽæIJĹçŽĎåĄIJåůěåĄIJäžğåŘŐ, çżŔæţŐäÿĂåőŽäijŽåŔŮåĹřéĞŊåĹŻ, åŻäæŋďåŕźäžŐçżŔæţŐçŽĎæĄćåďŊåĄŽåĞžéćĎæţŃåřśæŸ¿å¿ŮæŕŤè¿ČéĞŊèęĄ. 獜SARSåŘŐçŽĎæĄćåďŊæŻšçž£æİĕçIJţçŰńæČĔèŁĞåŘŐäijŽæIJĽåřŔåźĔåžęçŽĎåŔŊåijź. èĂŇäÿŤçňňäÿÄäžğäÿŽæĄćåďŊè¿Čå£ń, åIJĺçŰńæČĔåŎ翪æİ§åřśæIJIJţňňäžŇäžğäÿŽæňąäźŃ, çňňäÿĽäžǧäÿŽåĹŹæĄćåďŊéçåžęæIJĂæĔć. èĂŇå¡ŞäżŁçŽĎäÿŋåŻ¡çňňäÿĽäžǧäÿŽåŊäæŕŤæŻťåď¸gåŽäæŋďæIJĽçŘĘ獜çŻÿä£ąè£ŹæňąåůšçżŔåŕźäžŐçżŔæţŐçŽĎå¡śåŞŊèęĄè£IJè£IJåďǧäžŐSARS. 獜äžŐæŋďçśżåďǧåďňçĄ¿åŻæŋďäź§æšąæIJĽèűşåď§çŽĎæŢřæŊőåŕźæŋďçśżçĄ;åŘŐçžŔæţŐæĄćåďŊæĺąåđŃè£ŻèąŇåĹĘæđŘ, äžŐæŸŕåŕśæŋďä¡IJçjć

**åŻ; 3**èrtæŸŐäžĘ2003åźtéİđåĚÿæIJ§éŮtæűĹètźèĂĚä£ąå£ČãĂĄéćĎæIJ§ãĂĄæżąæĎŔæŇĞæŢřéČ¡æIJĽéŻłåťľåijŔçŽ äÿŊè£Ğ獜äžŐçŐřåIJĺ瞣äÿŁæűĹèťźæŰźåijŔçŽĎåďŽæăůæĂǧ, åČŔ2003åźtéĆčæăů鯳åťľåijŔäÿŃéŹŊçŽĎåśĂéİćäÿŊäÿĂ



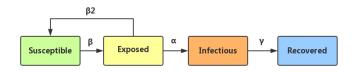
#### ä;£çŤĺæĺąåđŃéćĎæţŃçąőèŕŁæŢřéĞŔ.

æŋďæŰźæşŢæŸŕæIJĂå§žæIJňçŽĎ, äź§æŸŕæIJĂåőźæŸŞæČşåĹřçŽĎ, åźűäÿŤäÿžäžĘä¡£æĺąåđŃåĚůæIJĽèğčéĞŁæĎŔääÿĂèĹňäijŽä¡£çŤĺSIRæĺąåđŃåŠŇSEIRæĺąåđŃ. çśżäijijçŽĎçăŤçľűåIJĺçŰńæČĚæŮľæIJ§ä¿£æIJĽäžĘ翪æđIJ, åęĆèĕ£åőĽäžďěĂŽåďǧåŋęäÿŐåŁăæŃ£åďǧçžęåĚŃåďǧåŋęäżěåŔŁéŹŢèĕ£åÿĹèŇČåďǧåŋęåŘĹä¡IJåżžçńŃçŽĎäijăæŠŋåŁĺåŁŻ

alJĺæľČeaqaaŘĎæŰźelcaŻactaaŘŐ, æĹŚażňaŁŞaőŽa; £cŤĺSEIRæĺqađŃeĂŽeŁĞæIJžaŹĺaŋeaźacŽĎæŰźæsŢarźazŐcacea katilitation allowedzene katilitation allowe

# 3 SEIRæĺąåđŃåżžçńŃ

SEIRæĺąåđŃ[11][12][13][14][15]æŸfè¿ČäÿžæĹŘçʧåŠŇåÿÿçŤĺçŽĎæţĄèąŇçŮĚéćĎæţŃæĺąåđŃ, æĽĂçăŤçľűçŽĎäijă äÿŐçŮĚäžžæŐĕèğęè£ĞçŽĎåĄĕåžůäžžáźűäÿŊéľňäÿŁæĆčçŮĚ, èĂŇæŸfæĹŘäÿžçŮĚåŐ§ä¡ŞçŽĎæŘžåÿęèĂĚ.
æIJĽåĔşSARSçŽĎäijăæŠŋåŁĺåŁŻåŋęçäŤçľűåďŽæŢřéĞĞçŤĺçŽĎæŸfSIRæĹŰSEIRæĺąåđŃ. èŕĕæĺąåđŃæĺąæŃ§äžĘäijăæ§ŞçäżŐæŸŞæĎ§èĂĚåĹřæ¡IJäijŔèĂĚåĹřæĎ§æ§ŞèĂĚåĘŊåĹřåžůåďŊèĂĚ, éĂŽè£ĞåŘĎçŐfèŁĆçŽĎè¡ňåŇŰçŐĞãĂĄæšżæĎĹ县 4 åŊşäÿžæĺąåđŃçŽĎçďžæĎŔåŻ¿.



åŻ; 4: æĺąåđŃçďžæĎŔåŻ¿.

#### 3.1 äžžç;ďåĹŠåĹĘ

Sçśż, æŸŞæĎ§èĂĚ(Susceptible), æŸŕæŇĞæIJłå¿ŮçŮĚ, ä¡ĘçijžäźŔåĚŊçŰńèČ¡åŁŻ, äÿŐæĎ§æ§ŞèĂĚæŐĕèğęåŘŐæŸ Eçśż, æ¡IJäijŔèĂĚ(Exposed), æŇĞæŐĕèğęè£ĞæĎ§æ§ŞèĂĚ, ä¡ĘæŽĆæŮăèČ¡åŁŻäijăæ§ŞçżŹåĚűäżŰäžžçŽĎäžž, åŕźæ¡IJäijŔæIJ§éŢ£çŽĎäijăæ§ŞçŮĚéĂĆçŤĺïijŻ

Içśż, æĎ§æ§ŞèĂĚ( Infective ), æŇĞæ§ŞäÿŁäijăæ§ŞçŮĚçŽĎäžž, åŔŕäżěäijăæŠŋ翏SçśżæĹŘåŚŸïijŻ Rçśż, åžůåďŊèĂĚ( Recovered ), æŇĞèćń鎍çężæĹŰåŻăçŮĚæĎĹèĂŇåĚůæIJĽåĚŊçŰńåŁŻçŽĎäžž. åęĆåĚŊçŰńæIJ§æIJĽéŹŘ, RçśżæĹŘåŚŸåŔŕäżěéĞŊæŰřåŔŸæĹŘSçśż.

#### 3.2 åżžçńŃæŰźçĺŃ

æŇĞæăĞ	æĺąåđŃåŔĆæŢř
N	äžžåŔčæĂżæŢř
E	æ¡IJäijŔèĂĚåĹİåğŃåĂij
I	æĎ§æ§ŞèĂĚåĹİåğŃåĂij
S	æŸŞæĎ§èĂĚåĹİåğŃåĂij
R	æšżæĎĹèĂĚåĹİåğŃåĂij
$r_1$	æfŔäÿłæĎ§æ§ŞèĂĚæfŔåďľæIJĽæŢĹæŐĕèğęçŽĎåźşåİĞäžžæŢř
$r_2$	æŕŔäÿłæ¡IJäijŔèĂĚæŕŔåďĨæIJĽæŢĹæŐĕèğęçŽĎåźşåİĞäžžæŢř
$oldsymbol{eta}_1$	æĎ§æ§ŞèĂĔäijăæ§ŞæŋčåÿÿäžžçŽĎäijăæ§ŞæęĆçŐĞ
$eta_2$	æ¡IJäijŔèĂĔäijăæ§ŞæŋčåÿÿäžžçŽĎäijăæ§ŞæęĆçŐĞ
$\alpha$	æ¡IJäijŔèĂĚè¡ňåŇŰäÿžæĎ§æ§ŞèĂĚæęĆçŐĞ
γ	æŕŔåďľèćńæšżæĎĹçŽĎçŮĚäžžåŊăæĂżæŢřçŽĎæŕŤä¿Ń

翪åŘĹåőđéŹĚæČĚåĘţ, æŸŞæĎ§äžžç¿ďåIJĺäÿĂåijĂåğŃäijŽçżŔåŐĘæ¡IJäijŔæIJ§, äÿĂæőţæŮűéŮťåŘŐæĽŊåĞžçŐřç åŻăæŋďåĄĞèő¿æ¡IJäijŔèĂĚæŇĽçĚğæęĆçŐĞ $\alpha$ è¡ňåŇŰäÿžäÿžæĎ§æ§ŞèĂĚïijŽ

$$S_{n} = S_{n-1} - r_{1}\beta_{1}I_{n-1}\frac{S_{n-1}}{N}$$

$$E_{n} = E_{n-1} + r_{1}\beta_{1}I_{n-1}\frac{S_{n-1}}{N} - \alpha E_{n-1}$$

$$I_{n} = I_{n-1} + \alpha E_{n-1} - \gamma I_{n-1}$$

$$R_{n} = R_{n-1} + \gamma I_{n-1}$$

$$N = S + E + I + R.$$

ä¡ĘéĂŽè£ĞæŁěåfij, æŋďæňąçŽĎæŰřåĘǎèĆžçĆŐçŮĚæfŠåIJĺæ¡IJäijŔæIJ§äź§åĚůæIJĽçŻÿå¡ŞéńŸäijǎæ§ŞæĂğ, åŻǎæŋďæĹŚäżňåijŢåĚė $\beta_2$ äÿŐ $r_2$ , æ¡IJäijŔèĂĚäżě $\beta_2$ äijǎæ§ŞæęĆçŐĞåřĘåĄěåžůçŽĎæŸŞæĎ§èĂĚè¡ňåŔŸäÿžæ¡IJäijŔèĂĚ. èĂŇæ¡IJäijŔèĂĚæfŔåďľæŐěèğęçŽĎåĄěåžůæŸŞæĎ§èĂĚäžžæŢřäÿž $r_2$ . åŻǎæŋďèęĄåIJÍ $\frac{dS}{dt}$ åŠŇ $\frac{dE}{dt}$ äÿŋæůżåŁǎæ¡IJäijŔèĂĚäžőæŤźåŘŐçŽĎåĚňåijŔåęĆäÿŃïijŽ

$$\frac{dS}{dt} = -r_1 \beta_1 I \frac{S}{N} - r_2 \beta_2 E \frac{S}{N}$$

$$\frac{dE}{dt} = r_1 \beta_1 I \frac{S}{N} + r_2 \beta_2 E \frac{S}{N} - \alpha E$$

$$\frac{dI}{dt} = \alpha E - \gamma I$$

$$\frac{dR}{dt} = \gamma I$$

$$N = S + E + I + R.$$

ä£őæŤźåŘŐçŽĎè£ŋäżčæŰźçĺŃåęĆäÿŃïijŽ

$$S_{n} = S_{n-1} - r_{1}\beta_{1}I_{n-1}\frac{S_{n-1}}{N} - r_{2}\beta_{2}E_{n-1}\frac{S_{n-1}}{N}$$

$$E_{n} = E_{n-1} + r_{1}\beta_{1}I_{n-1}\frac{S_{n-1}}{N} + r_{2}\beta_{2}E_{n-1}\frac{S_{n-1}}{N} - \alpha E_{n-1}$$

$$I_{n} = I_{n-1} + \alpha E_{n-1} - \gamma I_{n-1}$$

$$R_{n} = R_{n-1} + \gamma I_{n-1}$$

$$N = S + E + I + R.$$

#### 4 åŔŕèaŇæĂğåĹĘæđŘ

è£ŚåźťæĬĕéŽŔçİĂæIJžåŹĺåŋęäźäåIJĺåŘĎçğŊåŘĎæăůåžŤçŤĺéćĘå§§çŽĎæĹŘåŁ§, èűŁæĬĕèűŁåďŽçŽĎéćĘå§§åijĂåğŃä åĄŔå¿őåĹĘæŰźçĺŃçŽĎçăŤçľűäź§æŸŕåĚűäÿŋäźŃäÿĂ[16]. åĄŔå¿őåĹĘæŰźçĺŃåĹďåőŽäÿżèęĄéIJĂèęĄèğčåĘşè£ŹæăůäÿĂ èĂČèŹŚäÿÄäÿłäÿÄèĹňçŽĎéİđ瞣æĂǧåĄŔå;őåĹĘæŰźçĺŃ

$$u_t = \mathcal{N}(t, x, u_x, u_{xx}, \dots), \tag{1}$$

åĚűäÿŋNæŸfäÿÄäÿłéİd瞣æĂğåĞ¡æŢř, èğŠæăĞäżčèąĺåĄŔå¿őåĹĘçŽĎæŰźåŘŚ. éĆčäźĹæĹŚäżň翏åőŽäžĘäÿĂçşżåĹŮæŢåĚűäÿŋxäÿžçľžéŮťäÿŋçŽĎç¡ŚæăijçĆź, $0 \le t \le M$ äÿžæŮűéŮťæĹş, æĹŚäżňèČ¡åŘęæăźæŊőçľžéŮťåĄŔåfijæŢřçŽĎæŢřæŊőæåIJÍæIJĂè£ŚçŽĎäÿÄ䞯çäŤçľűäÿŋ, æIJĽåŋęèĂĚéĞĞçŤĺäžĘçěđçżŔç¡ŚçżIJ(æůśåžęç¡ŚçżIJ)æİèåIJĺè£ŹæŰźéİćæIJĽäžĘäÿÅ

åęĆæđIJæĹŚäżňèČ¡åď§æIJĽäÿĂ䞯åŕźäžŐè£ŹäÿłæŰźçĺŃçŽĎåĚĹéłŇç§ěèŕĘ, æŕŤåęĆè£ŹäÿłæŰźçĺŃåďgæęĆæŸŕäÿĂä éĆčäźĹæĹŚäżňä¿£åŔŕäżĕéĂŽè£ĞåŋŮåĚÿåŋęäźăçŽĎæŰźåijŔæİĕåőŇæĹŘè£ŹæăůäÿÄäÿłäżżåŁą.

åŕźäžŐäÿĂäÿłåĚůæIJĽäžŇæňąåđŃéİđ瞣æĂğéąźçŽĎäžŇéŸűåĄŔå¿őåĹĘæŰźçÍŃ, æĹŚäżňåŔŕäżĕ翏åĞžåőČçŽĎäÿĀ

$$u_t = \alpha_1 + \alpha_2 u + \alpha_3 u^2 + \alpha_4 u_x + \alpha_5 u_x^2 + \alpha_6 u u_x + \alpha_7 u_{xx} + \alpha_8 u_{xx}^2 + \alpha_9 u u_{xx} + \alpha_{10} u_x u_{xx}$$
 (2)

è£ŹæăůçŽĎæŰźçĺŃçŽĎéŸűæŢřçŽĎçąőåőŽåŔŕäżěæăźæŊőçżŔéłŇåŔŁåĚű缾çŘĘæĎŔ䟼æĹŰèĂĚæŸŕéĂŽè£ĞæŢřåĂijaäÿŁéĬćçŽĎæŰźçĺŃ裟åŔŕäżěåĘŹæĹŘåŘŚéĞŔçŽĎå¡ćåijŔ,(åĚűäÿŋuäÿžäÿĂåĹŮåŘŚéĞŔ, u = (u(t, x1), . . . , u(t, xn))).

$$u_t = \begin{bmatrix} 1 & u & u^2 & u_x & u_x^2 & uu_x & u_{xx} & u_{xx}^2 & uu_{xx} & u_x u_{xx} \end{bmatrix} \alpha \tag{3}$$

å Ěűäÿŋæ ĹŚäżňå Ŕŕäż<br/>ěæ ŁŁåő Č塊çż Şäÿžäÿ Ăéąźæ Ÿŕåŋ Ůå Ěÿéąź<br/>Fu(t), äÿ Ăéąźæ Ÿŕçşżæ Ţřéąź $\alpha$ . é Ćčäź Lè£ Źäÿłæ Ůűå ĂŹæ Lé

$$\min_{\alpha} \frac{1}{2} \sum_{k=1}^{M} ||u_t(t_k) - F_U(t_k)\alpha||_2^2 + \lambda ||\alpha||_1$$
 (4)

æİèèŐůå¿Ůè£ŹæăůçŽĎåŘŚéĞŔ $\alpha$ , äżŐèĂŇåŕźäžŐ獜åŋŮåĚÿéĞŇçŽĎåĞ¡æŢřéĂŽè£Ğ瞣æĂğçżĎåŘĹèČ¡åď§èąĺè¿¿åĞžæ åĚűäÿŋ $L_1$ æŋčåĹŹéąźçŽĎæČľç¡ŽæŸŕæŕŤè¿ČèĞłçĎűçŽĎ,  $L_1$ èŇČæŢřæČľç¡Žå¿Ăå¿ĂèČ¡åď§ä¡£å¿ŮåŘŚéĞŔèűŃäžŐçĺ åŻääÿžåĚűåŕijæŢřçŽĎåÿÿæŢřæĂğèťĺ. åIJſæŰźçĺŃéŸűæŢřåćđåŁăæŮű, åŋŮåĚÿçŽĎåďgåřŔæŸŕæŇĞæŢřçžgåćđéŢ£çŽĎ, äÿŊè£ĞåĄŔå¿őåĹĘæŰźçĺŃäÿĂèĹňæŮǎæşŢåijăæżąæŢťäÿłåŋŮåĚÿ, å¿Ăå¿ĂéČ¡æŸŕåĚűäÿŋçŽĎåĞáéąźèţůçİÄä¡IJçŤĺ.
æĽÄäżėçĺĂçŰŔçŽĎèąĺçďžå¿Ăå¿ĂæŻťçňęåŘĹè£ŹæăůåĚůæIJĽçĽľçŘĘåŘń䟼çŽĎåĄŔå¿őåĹĘæŰźçĺŃçŽĎèğĎå¿Ń,
è£Źäź§çňęåŘĹåěĕåŊaåğĘçŽĎåĽČåĹĂåŐ§çŘĘ[18].

åŔęådŰäÿĂçğŊæĂİèůŕä¿£æŸŕäÿŊåŁăäÿŁè£ŹæăůåĄŔå¿őåĹĘæŰźçĺŃėİđ瞣éąźæŸŕäžŇæňąåđŃçŽĎåĄĞèő¿, 篝æŐĕä¡£çŤĺçěđçżŔç¡ŚçżIJæĬěåŐżè£Śäijijè£ŹæăůçŽĎėİđ瞣æĂğæĂğ, äź\$åřśæŸŕèŕťæĹŚäżňéIJĂèęĄäźãå¿ŮäÿĂäÿłç¡Śçź  $N(u,u_x,u_{xx})$ (æŻťéńŸéŸűçŽĎåŋŮåĚÿäź\$åŔŕäżěåőđçŐř). éĂŽè£ĞéĂĽæŃľæ£ĂæťżåĞ¡æŢřèů\$èřČæŢťç¡ŚçżIJèűĚåŔĆæŢřææĹŚäżňçŽĎæŰźæşŢçŽĎçĄţæĎ\$äź\$æŸŕæĬěæžŘäžŐè£ŹéĞŇ. èŹ¡äÿŊè£Ğè£ŹçğŊæŰźæşŢåIJĺåďšåŐżäžĘåĄĞèő¿çŽĎæČĚæĹŚäżňåźűäÿŊç\$ě饪è£ŹæăůçŽĎçěđçżŔç¡ŚçżIJåĹřåžŢèČ¡äÿŊèČ¡æĹŰèĂĚåIJĺäżÄäźĹçĺŃåžęäÿŁèąĺçďžäżÄäźĹå¡ćåijŔçźåźűäÿŤè£ŹæăůçŤĺçěđçżŔç¡ŚçżIJåďŊåŐ§åĞžæĬėçŽĎæŰźçĺŃåIJĺéŢ£æŮűéŮťçŽĎæijŤåŔŸäÿŋèČ¡åŘęçIJ§çŽĎè£ŚäijijåŐ§æ

äÿŊè£ĞSEIRæŸŕåďŽåĚČåÿÿå¿őåĹĘæŰźçÍŃ, éĂŽè£ĞåŔŸéĞŔæŻ£æŊćå¿ŮåĞžçŽĎåĄŔå¿őåĹĘèqĺè¿¿åijŔåĚűåőđæŸæĽÄäżĕåĚűåődçľűçń§è£ŹæäůçŽĎçěđçżŔç¡ŚçżIJèČ¡åŘęçIJ§çŽĎè£ŚäijijSEIRæĺqåđŃçŽĎåůőåĹĘ, æĹŚäżňåźűäÿŊåőŇåĚĺçåźűäÿŤè£ŹæăůçŽĎæŰźæşŢåIJĺçŘĘæČşçŽĎæİąäzűäÿŃçŽĎåĄŔå¿őåĹĘæŰźçÍŃæĄćåďŊäÿŋ, åůšçżŔ柿çŐřåĞžäžĘåŕźåŹæŢřåÄijäÿŁåŕźåĄŔåŕijæŢřçŽĎè£ŚäijijèőąçőŮçŽĎèŕŕåůőäijŽçťſçğf[19], åźűäÿŤç¡ŚæăijèűŁåfĘè£ŹæăůçŽĎèŕŕåůőåřśäijŽèűŁæĹŚäżňėlćäÿťçŽĎæČĚåĘţ獎èĞşæŻťåŁăåďŊæİĆ,æŢřæŊőæŻťæİĆäźśæŻťåřŚ,åŹłåčřåďŊæİĆ,åźűäÿŤåŔŕèČ¡èőŋçżČæăůæääÿŊè£ĞæĹŚäżň裟æŸŕåĘşåőŽèŕŢäÿĂèŕŢ.

## 5 æIJžåŹĺåŋęäźăæĺąåđŃåőđèůţ

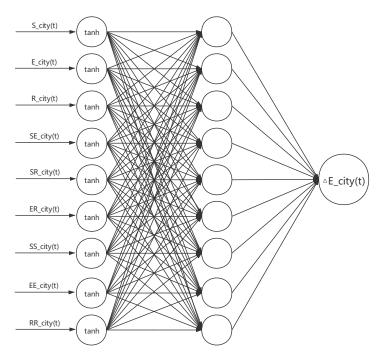
åęĆå $\mathbf{Z}_i$ 5 æĽÄçd $\mathbf{Z}_i$ 5 æĽÄçd $\mathbf{Z}_i$ 5 æĽÄçd $\mathbf{Z}_i$ 5 æĽÄçd $\mathbf{Z}_i$ 5 æĽÄçd $\mathbf{Z}_i$ 6 æŽ $\mathbf{Z}_i$ 6 æŽ $\mathbf{Z}_i$ 6 æŽ $\mathbf{Z}_i$ 6 æŽ $\mathbf{Z}_i$ 7 æŽ $\mathbf{Z}_i$ 8 æŽ $\mathbf{Z}_i$ 8 æŽ $\mathbf{Z}_i$ 8 æŽ $\mathbf{Z}_i$ 8 æŽ $\mathbf{Z}_i$ 8 æŽ $\mathbf{Z}_i$ 8 æŽ $\mathbf{Z}_i$ 8 æŽ $\mathbf{Z}_i$ 8 eŽ $\mathbf{Z}_i$ 8

åŻăäÿžæĹŚäżňçŽĎæŢřæŊőäÿŐåŐ§ådŊåŐ§åĄŔå¿őåĹĘæŰźçĺŃçŽĎæŢřæŊőéĞŔäÿŁåůőäžĘäÿŊæŋćäÿĂäÿłæŢřéĞŔç åźűäÿŤæĹŚäżňäź§åźűäÿŊç§ĕ饪SEIRæĺąåđŃäÿŋçŽĎåŘĎäÿłéĞŔåIJĺtæŮűåĹżçŽĎåĂij,äžŐæŸŕæĹŚäżňä¡IJåĞžäżĕäÿŃåA

- 1. äżěådŤäÿžæIJĂåřŔæŮűéŮťéŢ£åžę, èŹ¡çĎűæŢřæŊőæžŘæŸŕäżěåřŔæŮűäÿžåŊŢä¡Ŋçż§èőąçŽĎ, ä¡ĘæŸŕæĹŚäżňèőďäÿ è£ŹæăůçŽĎçż§èőąæŰźåijŔçijžäźŔçĺşåőŽæĂğ, çŻÿå¡ŞäžŐåŔŊèĂŇåćđåďğäžĘåŹłåčřäÿŐèŢťåŘńæIJĽæŢĹä£ąæĄŕäźľ
- 2. åŘĹåźűEäÿŐIéąź, èőąä¡IJE. åŕźäżżä¡ŢäÿĂäÿłå§ŐåÿĆäżĕåŻŻåďľåŘŐçŽĎçąőèŕŁäžžæŢřåĞŔåտ俣åďľçŽĎçąőèŕŁäžž
- 3. åřĘæ¡IJåIJÍæĎ§æ§ŞäžžæŢřèő¿äÿžåfĘåĹĞæŐĕèğęäžžæŢř, åźűäÿŤåŕźåfĘåĹĞæŐĕèğęäžžæŢřçąőèŕŁäžžæŢřä¡IJåĞžçžääżĕäijřèőqåŘĎäÿłå§ŐåÿĆåŘĎäÿłæŮűéŮťçŽĎæ¡IJåIJÍæĎ§æ§ŞäžžæŢř, ä¿İçĔğ2æIJĹ28æŮĕåĚňåÿČçŽĎ658587äÿžå§åŕźäžŐäÿÄäÿłå§ŐåÿĆåĘŊ獚è£ŹäÿłæĎ§æ§ŞäžžæŢřæŇĽæŕŤä¿ŃæŐĺçőŮåĞžtæŮűåĹżäźŃåĽŊçŽĎæĽÄæIJĽæĎ§æ

åřĘæĽĂæIJĽå§ŐåÿĆçŽĎéŽŔæIJžåĹĘäÿž80%èőŋçżČæŢřæŊőäÿŐ20%æţŃèŕŢæŢřæŊő, æſŔäÿÄäÿłæăůæIJňåŇĚæŃň åĘŊåIJĺèőŋçżČæŢřæŊőäÿŋçŽĎæŇĽå§ŐåÿĆåĹĘåĞž10%çŽĎėłŇèŕĄæŢřæŊő. æĂğèČ¡åžęéĞŔèő¿äÿžAbsolute mean error(åŻääÿžæĹŚäżň裟æŸŕèğĽå¿Ůè£ŹæăůçŽĎèąĺçďžåžŤèŕěæŸŕçŻÿåŕźçĺĂçŰŔçŽĎ), äijŸåŇŰçőŮæşŢèő¿äÿžéŽŔæ åŋęäźäçŐĞ0.03, æſŔåśĆç¡ŚçżIJ9äÿłtanhåŊŢåĚČ, äÿÄåĚśäÿďåśĆåĚĺè£đæŐě, æIJÄåŘŐäÿÄäÿłè¿ŞåĞžåŊŢåĚČ.

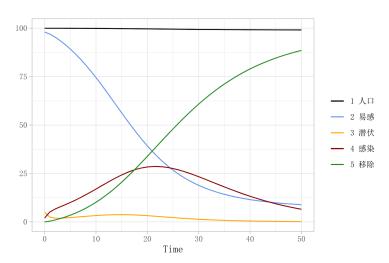
$$\min_{\mathcal{N}} \frac{1}{182 * 66} \Delta \sum_{\text{all } 182 \text{ cities on } 66 \text{ days}} \left| E_{city}(t) - \mathcal{N}(S_{city}(t), E_{city}(t), R_{city}(t)) \right|$$
 (5)



 $\mathring{a}\mathring{Z}_{i}$  5: çěđ<br/>çżÁç;ŚçżIJçďžæĎÁåŻ $_{i}$ .

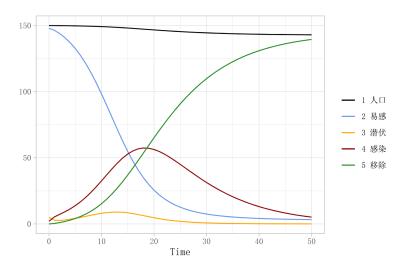
# 6 翪æđIJæčĂéłŇ

æĂĂçİĂ翪æđIJäÿŊäijŽçĽźåĹńåĕ¡çŽĎéćĎæIJ§, æĹŚäżňéŽŔæIJžåIJĺéłŇèŕĄéŻĘäÿŋéŽŔæIJžæŁ¡åŔŰäžĘåĞăäÿłå§ŐäÿŊåźÿçŽĎæŸŕ, 翪æđIJæŋčåĕ¡äÿŐæĹŚäżňçŽĎéćĎæIJ§äÿŊèřŃèĂŇåŘĹ. çňňäÿĂäÿłéłŇèŕĄå§ŐåÿĆæŸŕåŻŻåůİçIJĄçżţéŊ



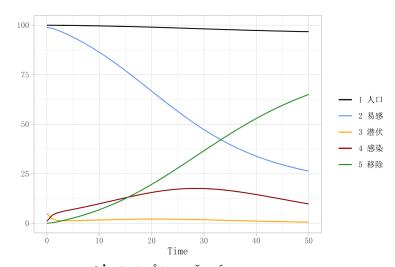
åŻ; 6: çżţéŸşéćĎæţŃ翪æđIJ.

å¿ŮåĹřçŽĎ翪æđIJåęĆ **åŻ¿6** æĽĂçďž, åŔŕäżěçIJŃåĹř, æĎ§æ§ŞäžžæŢřåşřåĂijçžęäÿž30äžž, è¿¿åĹřåşřåĂijçŽĎæŮűéŮťäÿž èĂŇåĹř2020.2.28æŮě, çżţéŸşçŽĎåőđéŹĚæĎ§æ§ŞäžžæŢřåŔłæIJĽ22äžž, éćĎæţŃ翪æđIJäÿŐåőđéŹĚçŽĎæŢřæŊőäÿŊæŸ



åŻ; 7: å¿ůåůđéćĎæţŃ翪æđIJ.

çňňäžŇäyłæŁ¡åŔŰåĹřçŽĎéłŇèŕĄå§ŐåÿĆæŸŕåśśäÿIJçIJĄå¿ůåůđåÿĆ, 翪æđIJåęĆ **åŻ; 7** æĽĂçďž, åŔŕäżĕçIJŃåĹř,æĺąåđŃåŕźäžŐå¿ůåůđåÿĆçŽĎæĎ§æ§ŞäžžæŢřäijřèőąè¿¿åĹřäžĘåřĘè£Ś60äžž,äź\$äÿŐåőđéŹĚæŢřæŊőçŻÿåůåźűäÿŤæŋżäžąäžžæŢřäz§è£IJè£IJéńŸäžŐæŁě饪çŽĎ2äžž.



åŻ; 8: åŊŮåőĄéćĎæţŃ翪æđIJ.

çňňäÿĽäÿłæŁ¡åŔŰåĹřçŽĎå§ŐåÿĆæŸŕåź£èĕ£éŢ£æŮŔèĞłæšżåŇžçŽĎåŊŮåőĄåÿĆ,翪æđIJåęĆå**Ż¿**8
æĽĂçďž,ä¡ĘåődeŹĚäÿŁåŊŮåőĄåÿĆçŽĎæĎ§æ§ŞäžžæŢřåIJÍ2020.2.28è£ŹäÿĂåďle¿¿åĹřäžĘ55äžž. åŻäæŋďećĎæţŃåĂijäÿçźŔè£ĞäżĕäÿŁäÿŁäÿłå§ŐåÿĆçŽĎæŁ¡åŔŰæčĂæţŃ,åŔŕäżĕåĹİæŋĕåŔŚçŐřæĹŚäżňæĽĂèőŋçżČåĞžæİĕçŽĎæÍąåđŃåźűåődeŹĔäÿŁ,åIJĺełŇèŕĄeŻĘçŽĎ20äÿłå§ŐåÿĆäÿŋè£ŻèąŇełŇèŕĄ,èŕŕåůőåÄijè¿¿åĹřäžĘ0.368347,åŔŕèğĄ,æŋďæŰźæşŢèőŋçżČåĞžæİeçŽĎæÍąåđŃåźűäÿŊèČ¡èŕťåőČæŸŕæĹŘåŁ§çŽĎ.

## 7 翪æđIJåĹĘæđŘ

åŕźäžŐäÿžä¡ŢäijŽæIJĽæŋčçąőçŐĞåĄŔä¡ŐçŽĎèőŋçżČæĺąåđŃ,æĹŚäżňçżŔè£ĞèőĺèőžåŘŐ,å¿ŮåĞžçŽĎ翪èőžåęĆäÿľ

#### çňňäÿĂçğŊåŐ§åŻă.

éęŰåĚĹè£ŹæăůçŮĚæŕŠäijăæŠŋçŽĎçIJ§åőđæŢřæŊőæŸŕéİdåÿÿådŊæİĆçŽĎæÍąåđŃ, åŻääÿžäÿŊåŘŇå§ŐåÿĆçŽĎéčŐä èţřäžšèő£åŔŃçŽĎéćŚçźĄçÍŃåžęäź§æIJĽæĽĂåůőåijĆ. åőČäÿĂæŰźéİċåŔŮåĹřå§ŐåÿĆåŇżçŰŮæřťåźşçŽĎå¡śåŞŊ, åŔęäÿĂæŰźéİċäź§åŔŮåĹřæŤ£åžIJåőŸåŚŸäżěåŔŁèŕĕåÿĆåśĚæřŚçŽĎéĞŊèğĘçÍŃåžęçŽĎå¡śåŞŊ. åŘŇæŮű, æIJĽäÿĂ䞯éĞŊçŮĞåIJřåŇžè£ŸäijŽæIJĽåŻ¡åőűçŽĎéĞŊçĆźæŤŕæŔť. åŻăæŋdè£ŹçğŊçŰ¿çŮĚäijăæŠŋçŽĎæŢřæŊőæŸŕå èęĄä¡£çŤÍäÿÄäÿłçĕđçżŔç¡ŚçżIJæİĕäijřèőąåęĆæŋdådŊæİĆçŽĎæÍąåđŃ, éIJĂèęĄçŽĎæůśåžęäżěåŔŁæŢřæŊőéĞŔåŊĄåĹĘå äÿŊåźÿçŽĎæŸŕ, æŋdæňąçäŤçľűäÿŋ, è£ŹäÿdçĆźæĹŚäżňéČ¡äÿŊåĚůådĞ. éęŰåĚĹæĹŚäżňæĽĂæđĎåżžçŽĎçěđçżŔç¡ŚçżIJåŔ åźűäÿŊèČ¡åd§åŋęäźäåĞžåĚůæIJĽåęĆæŋdådg¸čŽĎæůsåžęçŽĎæíąåđŃ. åŔęäÿĂæŰźéİć, æĹŚäżňæĽĂæŃěæIJŁçŽĎæŢřæŊő åŔłæŃěæIJĽ253äÿłå§ŐåÿĆçŽĎæŢřæŊő, è£ŹæăůçŽĎæŢřæŊőèęĄèŐŋçżČåęĆæŋdåďg¸čŽĎäÿÄäÿłç¡ŚçżIJæŸŕè£ŚäźŐäÿ

#### çňňäžŇçğŊåŐ§åŻă

åIJĺeőŋçżČe£ĞçĺŃäÿŋ, åČŔäÿŁäÿĂæİąåĹĘæđŘçŽĎäÿĂæăů, æĹŚäżňçŽĎeőŋçżČæăůæIJňäÿŋçŽĎæŢřæŊőåŔŕeČ¡æIJiäżŰäżňåŇĚåŘńçŽĎä£ąæĄŕåźűäÿŊæŸŕåĔşäžŐåŘŇäÿÄäÿłæĺąåđŃçŽĎæŢřæŊő. åIJĺe£ŹæăůçŽĎçŮĚæŕŠäijäæŠŋæĺąåđŃäÿåĚűäijäæŠŋæĺąådínå¿ĹæIJĽåŔŕeČ¡æŸŕä¿İæŊőå§ŐåÿĆçŽĎåőćèğĆæİąäżűåĹĘçśżåŋŸåIJĺçŽĎ, åŕźäžžåŔčæţĄåŁĺçŽĎećŚçŐĞæřŤæÿľçŤŽeĞşåŇżeŹċçŽĎåőźçžşeČ¡åŁŻçŋĽåŔĆæŢřåŔŕeČ¡æIJĽçlĂPhase TransitionçŽĎçŐřèsą. åIJĺå§ŐåÿĆçŽĎåřžåžęäÿŁæIJĽè£ŹæăůçŽĎçŐřèsą, åIJĺäÿŊåŘŇçŽĎåIJřçŘĘåřžåžęäÿŁeČ¡äijŽæIJĽè£ŹææŕŤåęĆåŕźæŕŤæŋæsĽäÿŐèě£èŮŔ,äÿŋåŻ¡äÿŐèŃśåŻ¡å¿ĹæŸŐ柿çŮĚæŕŠåźűäÿŊæIJŊäżŐåŘŇæăůçŽĎåćđeŢ£æĺąåijŔ. èĂŇæĹŚäżňçŽĎæĺąåđŃeĞŇçŽĎåIJřçŘĘäÿŁçŽĎåřžåžęąůďķåřŔ, ä¡£å¿ŮåIJĺå§ŐåÿĆeĞŇçŽĎè£ŹæăůçŽĎçŐřèśąèČjåď§å;śå

#### çňňäÿĽçğŊåŐ§åŻă.

æĹŚäżňåIJĺåŕźäžŐè£Źäÿłå¿őåĹĘæŰźçĺŃæśĆèğčçŽĎè£ĞçĺŃäÿŋ, éĂŽè£ĞåŋŮåĚÿåŕźäžŐåŔĆæŢřè£ŻèąŇè£Śäijij, åŻăæŋď, åŋŮåĚÿçŽĎæđĎåżžåřśæŸ¿å¿ŮåřďäÿžéĞŊèęĄ. æĽÄäżėäź§æIJĽåŔŕèČ¡æŸŕåŻääÿžåŋŮåĚÿæđĎåżžçŽĎäÿŊåď§åő éĞŇéľćæŮăæşŢ獧æĹŘåĞžæŰźçĺŃäÿŋåőđéŹĚåŘńæIJĽçŽĎéąź. æĽÄäżěåęĆæđIJèęĄè£ŻäÿÄæŋěçäŤçľű, åřśå¿ŮèĂČèŹŚæđĎåżžäÿÄäÿłæŻťåŁäåőŇåŰĎæŻťåŁäåŘĹçŘĘçŽĎåŋŮåĚÿ.

#### çňňåŻŻçğŊåŐ§åŻă.

åŻăäyžåŻ¡éŹĚäyŁåŕźäžŐäijăæ§ŞçŮĚæĺąåđŃçŽĎéćĎæţŃåďŽæŸŕä¿İéİäåżžçńŃäijăæ§ŞçŮĚåŁĺåŁŻåŋęæĺąåđŃ, çĎűåŘŐæśĆèğčæŰźçĺŃ, åźűäÿŊçżŔåÿÿä¡£çŤĺçěđçżŔç¡ŚçżIJè£ŹäÿĂæŁĂæIJŕ, äź§åŔŕèČ¡èŕťæŸŐäžĘçěđçżŔç¡ŚçżIJè£Źäÿ åŻăæŋď, æČşèęĄåŔŰå¡ŮæŻťåŁäè£ŻæŋĕçŽĎçăŤçľű, åŔŕèČ¡èęĄèĂČèŹŚåĚűäżŰçŽĎæIJžåŹĺåŋęäźăæŰźæṣŢ.

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