ČESKÉ VYSOKÉ
UČENÍ TECHNICKÉ
V PRAZE

F3

Fakulta elektrotechnická
Katedra kybernetiky

Bakalářská práce

Expertní systém pro určování dominantní projevované emoce z hlasu

Jakub Šmíd
Kybernetika a robotika

20. května 2022
Vedoucí práce: Ing. Jan Hejda, Ph.D.

ZADÁNÍ BAKALÁŘSKÉ PRÁCE

I. OSOBNÍ A STUDIJNÍ ÚDAJE

Příjmení: **Šmíd** Jméno: **Jakub** Osobní číslo: **483554**

Fakulta/ústav: **Fakulta elektrotechnická**

Zadávající katedra/ústav: **Katedra kybernetiky**

Studijní program: **Kybernetika a robotika**

II. ÚDAJE K BAKALÁŘSKÉ PRÁCI

Název bakalářské práce:

Expertní systém pro určování dominantní projevované emoce z hlasu

Název bakalářské práce anglicky:

Expert System for Determining the Dominant Expressed Emotion from the Voice

Pokyny pro vypracování:

Cílem práce je návrh expertního systému pro identifikaci dominantní projevované emoce z hlasu mluvčího. Navržený systém bude schopen určovat příslušnost hlasem projevované emoce k jedné ze šesti sledovaných kategorií vycházejících z teorie základních emocí [4] a využívaných v současných validovaných datasetech. V rámci práce bude dále simulací otestována přesnost systému při analýze hlasu z VHF/UHF vysílaček.
Student v rámci práce analyzuje a použije dostupné relevantní validované datasety (EmoDB, RAVDESS, CREMA-D) a metody pro hodnocení hlasu. Vybranou metodu následně implementuje a na základě experimentů navrhne její parametry pro klasifikaci. Student otestuje přesnost systému pro jiné slovní fráze než ty, které byly součástí trénovací a validační množiny.
Hlavní úkoly:
1) Analyzujte dostupné validované datasety EmoDB, RAVDESS a CREMA-D.
2) Navrhněte metodu analýzy hlasu včetně její architektury, augmentace dat a případné extrakce příznaků.
3) Na základě experimentů navrhněte parametry vytvořeného systému a srovnejte jeho přesnost s jinými state-of-art řešeními.
4) Otestujte a zhodnoťte přesnost systému pro jiné slovní fráze než ty, které jsou součástí trénovací a validační množiny.
5) Simulací omezením frekvenčního pásma a přidáním umělého šumu otestujte a zhodnoťte přesnost systému při analýze hlasu z VHF/UHF vysílaček.
6) V jazyce Python implementujte aplikaci pro demonstraci navrženého systému.

Seznam doporučené literatury:

[1] Fayek, Haytham M., Margaret Lech, and Lawrence Cavedon. "Evaluating deep learning architectures for Speech Emotion Recognition." Neural Networks 92 (2017): 60-68
[2] Seehapoch, Thapanee, and Sartra Wongthanavasu. "Speech emotion recognition using support vector machines." 2013 5th international conference on Knowledge and smart technology (KST). IEEE, 2013
[3] Swain, Monorama, Aurobinda Routray, and Prithviraj Kabisatpathy. "Databases, features and classifiers for speech emotion recognition: a review." International Journal of Speech Technology 21.1 (2018): 93-120
[4] Ekman, Paul. "An argument for basic emotions." Cognition & emotion 6.3-4 (1992): 169-200

Jméno a pracoviště vedoucí(ho) bakalářské práce:

Ing. Jan Hejda, Ph.D. katedra zdravotnických oborů a ochrany obyvatelstva FBMI

Jméno a pracoviště druhé(ho) vedoucí(ho) nebo konzultanta(ky) bakalářské práce:

Datum zadání bakalářské práce: **28.01.2022** Termín odevzdání bakalářské práce: **20.05.2022**

Platnost zadání bakalářské práce: **30.09.2023**

Ing. Jan Hejda, Ph.D.	prof. Ing. Tomáš Svoboda, Ph.D.	prof. Mgr. Petr Páta, Ph.D.
podpis vedoucí(ho) práce	podpis vedoucí(ho) ústavu/katedry	podpis děkana(ky)

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III. PŘEVZETÍ ZADÁNÍ

Student bere na vědomí, že je povinen vypracovat bakalářskou práci samostatně, bez cizí pomoci, s výjimkou poskytnutých konzultací.
Seznam použité literatury, jiných pramenů a jmen konzultantů je třeba uvést v bakalářské práci.

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Datum převzetí zadání	Podpis studenta

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Poděkování / Prohlášení

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Abstrakt / Abstract

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Title translation: N²qO}§ ~´ §Oh Tn} KO§O}h_j_jX §\O Knh_j9j§ N²q}O OL Nhn§_nj T}nh §\O -n_HO

/ Obsah

1 Úvod **1**

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vání emocí z hlasu **2**

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3 Neuronové sítě **6**

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5 Datasety pro rozpoznávání
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Kapitola 1
Úvod

~ OhnHOh_ O O§c¾®¾hO ®ę_H\j_ c9^L↓ LOjJ qneOċjĽ aO q}n^ə®¾hO 9 ®jəh¾hO q}naO®´ OhnHə L}«\↓H\ n n@J c§O}Ĺ qn§c¾®¾hOu -jəh9jĹ OhnHO ¶ j9ęO\n ncneə O hn\n« ęə Ą§ ¶qĽ§ j9 j¾ u NhnHO hĽjə j9ęO qnH_§´ 9 n®e_®ŭ«aə j9ęO H\n®¾jəJa n« a9cn« _@O¶q}n §ĄOLjə }O9cHə j9 ®jĽaęə qnLjĽ§´u

Ċen®Ľc Lnc¾^O qnhĽ}jĽ j9Ljn nL\9Ljn«§ 9 qnq 9§J a9cĹ OhnHO q}n^ə®¾ 9c§Ĺ}J c§O] }Ĺ\n aOL_jOH qn¶n}«aO jO@n qn en«H\¾u |n¶qn¶j¾®¾jə e_L c↓H\ OhnHə aO ®ę9c q}n qnċə§9ċO qnhĽ}jĽ j¾}nċj↓ q}n@eĹhu i¾}nċjn § aO ¶qţ n@Oj9 §əhJ ^O ^¾Lj¾ hĽĄ§Oej¾ ®Oe_ċ_j9 jOjə qĄəhn ¶¾®_ e¾ j9 q}naO®n®9jĹ OhnH_u NhnHO §OL´ jOe¶O hĽĄ§ ^¾Lj↓h Oj¶n}OhU iOe¶O 9j_ j9 §9®_§ ^¾Lj¾ aOLjnL«H\¾ q}9®_Le9J qnLeO c§O}↓H\ @´ @´e §}na H\nqj↓ O }n¶\nLn®9§ 9 }n¶qn¶j¾®9§ e_L cĹ OhnHOu

p}naO®n®9j¾ OhnHO O ®↓}9¶jĽ q}nhə§jO ® }LOċjə T}Oc®OjH_ aOL_jHOJ ® aO\n c}O®jəh §e9c« jO@n ® hn¶cn®↓H\ ®ej¾H\u 8@´H\nh ¶ə c9e_ §9§n L9§9J qn§ĄO@«aOhO ¶L}9®n§j_HcĹ ¶9Ąə¶Ojə 9 ®´ęcneOj↓ qO} nj¾eJ Hn^ jOjə q}9c§_HcĹ q}n c9^LnLOjjə qn«^_§əu p}n§n O }n¶®naOh «hĽeĹ _j§Oe_XOjHO ® qn eOLjəH\ jĽcne_c9 eO§OH\ }n¶®_j«e´ _ ®↓¶c«h´J c§O}Ĺ O ¶9@↓®9aə }n¶qn¶j¾®¾jəh OhnHə ¶ 9«L_n®_¶«¾ejə\n h9§O}_¾e«J c§O}↓ hţ^OhO qnĄəL_§ @Ľ^jn« c9hO}n« jO@n h_c}nTnjOhu -↓cnjjĹ qnċə§9ċO «hn^ŭ«aə j9§}Ĺjn®9§ }n¶ ¾\eĹ jO«}njn®Ĺ ə§ĽJ c§O}Ĺ «hə n@Ln@jĹ q}n@eĹh´ OTOc§_®jĽ ĄOę_§u

pnċə§9ċn®Ĺ }n¶qn¶j¾®¾jə e_L c↓H\ OhnHə \}9aO LţeO^_§n« }ne_® n@e9 §OH\J c§O}↓h_a n« j9qĄəce9LI Lnq}9®9 r}n¶qn¶j¾®¾jə §9®« Ą_L_ċO jO@n q_en§9sJ @O¶qOċjn § r eOLn®¾jə OhnHə ®O ®OĄOaj↓H\ q}n §n}OH\sJ ¶¾c9¶j_Hc¾ ¶qĽ§j¾ ®9¶@9 r9«§nh9§_HcĹ ®´\nLjnHOjəsJ qnċə§9] ċn®Ĺ \}´ r9L9q§9HO \}´ ® ¶¾®_ en §_ j9 OhnHəH\ \}¾ċOsJ ¶L}9®n§j_H§®ə r®´\nLjnHn®¾jə §}O n®Ĺ ¶¾§Ľ^OsJ 9 hjn\9 L9eęəH\u

GəeOh §Ĺ§n q}¾HO aO j9®}\jn«§ ´ §ĹhJ c§O}↓ Lnc¾^O Hn jOaęĹqO ¶9Ą9L_§ ¶®«cn®n« j9\}¾®c« he«®ċə\n Ln aOLjĹ ¶ ęO §_ eOLn®9j↓H\ OhnHəu b §nh« aO j«§jĹ jOaLĄə®O 9j9] e´¶n®9§ Ln §«qjĹ L9§9 O§´ ¶®«cn®↓H\ j9\}¾®OcJ c§O}Ĺ h9aə qĄ_Ą9¶Ojn« OhnH_J c§O}¾ aO ® j_H\ ¶9H\´HOj9u K¾eO O q}¾HO ¶9@↓®¾ 9j9e↓¶n« 9 j¾®}\Oh hO§nL´ q}n 9j9e↓¶« \e9 «u ¦O §n®¾jə ´ §Ĺh« aO q}n®OLOjn j9 ®Ľ§Ľ a_jĹJ jO^ c§O}¾ @´e9 qn«^_§9 qĄ_ §®n}@Ľ §n\n§n ´ §Ĺh«u `Oe_cn^ _j§O}cnh´ jO@n ®´ əe9ċc´ qĄOj¾əə ¶®«c ® \n}ęə c®9e_§ĽJ jO^ ® a9cĹ a n« H\nqjĹ \n ¶9¶j9hOj9§J @«LO qĄO jn § ´ §Ĺh« n§O §n®¾j9 _ qĄ_ _h«e9H_ §ĽH\§n ¶\n}] ęOj↓H\ qnLhəjOcu pn eOLjəh ωcneOh §Ĺ§n q}¾HO aO ®´®_j«§ə 9qe_c9HOJ c§O}¾ }n¶qn¶j¾®¾ OhnHO ® }O¾ejĹh ċ9 O ¶O _Xj¾e« ¶ə c9jĹ\n ¶ h_c}nTnj« qnċə§9ċOu

Kapitola 2
Metody řešení rozpoznávání emocí z hlasu

NhnHOJ c§O}Ĺ a n« ® §Ĺ§n q}¾H_ qn«^_§´ hţ^OhO n¶j9ċ_§ ¶9 ¶¾ce9Ljđ OhnHOu p9«e Nch9j ¯u -u S}_O OjOh LO»jn®9e_ ¶¾ce9Ljđ OhnHO a9cn «j_®O}¶¾ejđ OhnHO O \nLj↊h q}naO] ®Oh j9qĂđċ c«e§«}9h_u pnLeO j_H\ hO¶_ ¶¾ce9Ljđ OhnHO q9§Ăđ eO § OhnHđI e§Ľ §đJ h«§OcJ qĂOc®9qOjđJ §}9H\J ®¶§Oc 9 ¶jOH\«HOjđu Nch9j S}_O OjOh qĂOLce¾L9e_ Tn§nX}9»O n@] e_ċOaţ rc§O}Ĺ ¶9H\´Hn®9e´ nj´ LO»jn®9jĹ OhnHOs Lnhn}nLHţh ¶ chOjO Sn}O j9 in®Ĺ W«_jO_u Knhn}nLH_ Lnc¾¶9e_ qĂ_Ă9L_§ Tn§nX}9»O qĂO jĽ §9cJ a9c aO ®jđh¾ ¶¾q9Ljđ qneOċ] jn §u µ qnL §9§´ O²qO}_hOj§« O e¶O §9cĹ Lnh jđ®9§J ^O ®↊}9¶ ® n@e_ċOa_ aOL_jHO Lnc¾^O nL\9e_§J a9cn« OhnH_ aOL_jOH ®´a9LĂ«aOu ~§OajĽ §9c ®}n¶Oj¾ }O9cHO j9 ®¶§Oc r¶®↊eOjđ §e9c«J ¶}´H\eOjđ §Oq«s aO qĂ_}n¶Oj¾ q}n ®eOH\j´ e_L_u µ¾ce9Ljđ OhnHO @´ O §OL´ hĽe´ q}naO®_§ _ ® \e9 O 9 §´§n q}naO®´ @´ hĽe´ @↊§ j9®¶¾aOh jO¶¾®_ eĹJ nLe_e_§OejĹu EoŚ©F

pĂ_Ă9¶Ojđ ¶®«cn®↊H\ j9\}¾®Oc c aOLjn§e_®↊h OhnHđh O j9¶↊®¾ ce9 _»c9HOu be9 _»] c9HO aO n@OHjĽ q}n@eĹhJ c§O}↊ ĂOeđ 9eXn}_§h« j9¶↊®9j↊ ce9 _»c¾§n}u g¾hO]e_ jĽa9c↊ n@aOc§J c§O}↊ q9L¾ Ln aOLjĹ ċ_ ®đHO §Ăđ L rc9§OXn}_đJ e9@OeţsJ q9c aO ωcneOh ce9 _»c¾] §n}« j9ađ§ qĂ_Ă9¶Ojđ njn\n n@aOc§« cO q}¾®jĹ §Ăđ LĽ jO@n cO q}¾®j↊h §Ăđ L¾hu - j9eOh qĂđq9LĽ aO §Oj§n jO¶j¾h↊ n@aOc§ ¶®«cn®¾ j9\}¾®c9 \e9 « he«®ċđ\n 9 c9§OXn}_O a n« aOLjn§e_®Ĺ ¶¾ce9Ljđ OhnHOJ cO c§O}↊h @«LO j9\}¾®c9 qĂ_Ă9¶Oj9u i9eđh HđeOh aO qĂ_Ă9L_§ aOLj« j9\}¾®c« ®^L´ c aOLjĹ ¶ OhnHđJ q}n§n q}n@eĹh hţ^OhO cnjc}Ĺ§jĽa_ n¶j9ċ_§] aOLj¾ O n h«e§_]He9 ce9 _»c9H_ rqĂ_Ă9¶Ojđ c aOLjĹ ¶ ®đHO §Ăđ Lsu

p}n§n^O jOe¶O n@OHjĽ 9 aOLjnL«eO qnq 9§ q}9®_Le9J c§O}¾ «}ċ«ađ ®↊ c´§ L9jĹ OhnHO ® \e9 n®Ĺ j9\}¾®HOJ jOhţ^OhO 9j_ ®´§®nĂ_§ q}nX}9hJ c§O}↊ @´ qnLeO §Ľ H\§n q}9®_LOe ce9] _»cn®9eu i_HhĹjĽ hţ^OhO ce9 _»c9H_ ĂOe_§ hO§nL9h_ §}nan®Ĺ\n «ċOjđ raOLj9 ¶ hO§nL «hĽeĹ _j§Oe_XOjHOsJ c§O}Ĺ Lnc¾^O OTOc§_®jĽ §9§n q}9®_Le9 j9eĹ¶§ qĂ_ Ln §9§c« §}Ĺjn®9HđH\ L9§J ¶O c§O}↊H\ O @«LO §}na «ċ_§ j¾h jO¶j¾hĹ n«®_ en §_u ~§}nan®Ĺ «ċOjđ aO §9c§n H\nqjĹ ®´§®nĂ_§ hnLOeJ c§O}↊ h¾ j9«ċOj¾ q}9®_Le9 q}n ce9 _»c9H_u pnLeO §n\n§n j9§}Ĺ] jn®9jĹ\n hnLOe« a hO q9c H\nqj_ ce9 _»cn®9§ j9\}¾®c´u

p}n }n¶qn¶j¾®¾jđ OhnHđ ¶ \e9 « O jOaċ9 §Ľa_ qn«^đ®¾ hO§nL9 qnLqţ}j↊H\ ®Oc§n}ţ r~«qqn}§ -OH§n} g9H_jO sJ e_jO¾}jđ }OX}O O rg«e§_®9}_9@eO d_jO9} |OX}O _njs jO@n jO«}njn®Ĺ đ§Ľu E¨ŚE£F ¦9@«ec9 ©uo ¶n@}9¶«aO h9²_h¾ejđ q}ţhĽ}jn« Ln 9^Ojn« qĂO jn § ® ¶¾®_ en §_ j9 }ţ¶j↊H\ ce9 _»c¾§n}OH\u

gO§nL´	p}ţhĽ}j¾ qĂO jn § E t F
gO§nL9 qnLqţ}j↊H\ ®Oc§n}ţ	¢£uVP
-đHO}n¶hĽ}j¾ e_jO¾}jđ }OX}O O	£Puk·
|Oc«}Oj§jđ jO«}njn®¾ đg	¢ku©·
bnj®ne«ċjđ jO«}njn®¾ đg	P¨u£o

Tabulka 2.1. pĂO\eOL qĂO jn §đ ce9 _»c9HO 9 aOLjn§e_®↊H\ hO§nL qnLeO E¨Fu

`O ®e9c j«§jĹ LnL9§J ^O Ln 9^Oj¾ qĂO jn § ce9 _»c¾§n}« ¶¾®_ đ jOaOjnh j9 ®´@}9jĹ hO§nLĽJ 9eO _ j9 ®↊@Ľ}« L9§9 O§« rjO@n aOa_H\ cnh@_j9HđsJ hjn^ §®đ §Ăđ LJ Ln c§O}↊H\ ce9 _»c«aOhO jO@n j9 ¶q}9Hn®¾jđ L9§ qĂOL ce9 _»c9Hđu

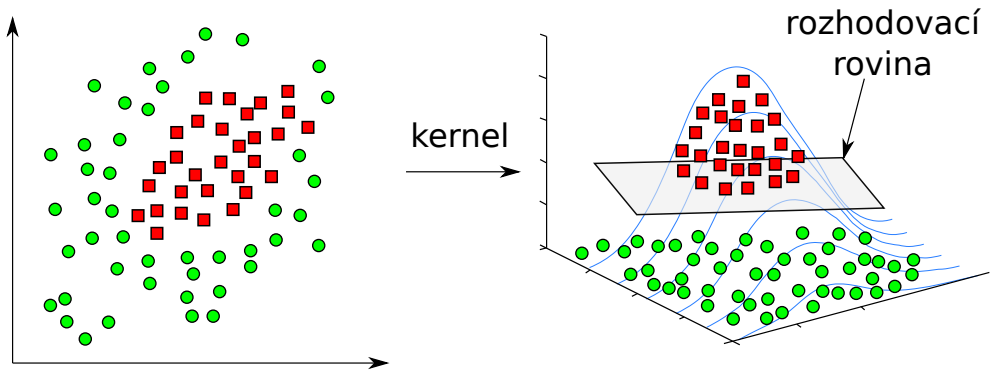
2.1 Metoda podpůrných vektorů

g O§nL9 aO §9cĹ ¶j ¾h ¾ qnL 9jXe_Hc ł h j ¾¶®Oh ~«qqn}§ -OH§n} g 9H_jO ċ_ qnL ¶c}9§cn« ~- gu gO§nL9 O qn«^ð®¾ q}n ce9 _»c9H_ jO@n q}n }OX}O jð ωen\´u

[e9®jð h´æeOjcn« 9eXn}_§h« aO §}9j Tn}h9HO qţ®nLjðH\ ® §«qţ r® §«qjðH\ qÄð¶j9cţs L9§9 O§« Ln®´ ncnL_hOj¶_nj¾ejð\n q}n §n}« ¶9 qn«^_§ð a¾L}n®Ĺ T«jcHO rcO}jOe T«jH§_njsJ 9 qn§Ĺ Ln 9^Ojð nq§_h¾ejð ce9 _»c9HO ® §nh§n jn®Ĺh q}n §n}«u Kðc´ §Ĺ§n §}9j Tn}h9H_ e¶O ce9 _»cn®9§ _ e_jO¾}jĽ jO Oq9}n®9§Oejð ® §«qjð L9§9u

be9 _»c9HO L9§ q}n@ð\¾ \eOL¾jðh nq§_h¾ejðH\ j]L_hOj _nj¾ejðH\ \´qO}}n®_jJ c§O}Ĺ nq§_h¾ejĽ }n¶LĽe«að L9§9 j9 qn^9Ln®9jĹ c9§OXn}_O r§ÄðL´su b \eOL¾jð nq§_h¾ejðH\ \´] qO}}n®_j O ®´«^ð®¾ §¶®u qnLqţ}jłH\ ®Oc§n}ţJ Hn^ a n« @nL´ ® q}n §n}«J c§O}Ĺ }Oq}O] ¶Ojł§«að §}Ĺjn®9Hð L9§9J c§O}¾ a n« jOa@eð^O c \´qO}}n®_jĽu mq§_h¾ejð \´qO}}n®_j9 aO q9c §9cn®¾ \´qO}}n®_j9J c§O}¾ h9²_h9e_¶«aO ®n« ®¶L¾eOjn § nL §ĽH\§n qnLqţ}jłH\ ®Oc§n}ţu E¢F

m@}¾¶Oc ©uo ¶j¾¶n}ŭ«aOJ a9c T«jX«aO ~- gu i9 eO®Ĺ §}9jĽ h¾hO ® §«qjð L9§9 ®O ©K q}n §n}«J c§O}¾ H\HOhO 9«§nh9§_Hc´ ce9 _»cn®9§ Ln ¶OeOjĹ 9 ċO}®OjĹ §ÄðL´u pn«^_§ð h a¾L}n®Ĺ T«jcHO §9§n L9§9 §}9j Tn}h«aOhO Ln q}n §n}« ®´æeð L_hOj¶Ou pn§Ĺ j9eO¶jOhO }n®_j«J c§O}¾ aO ¶9c}O eOj9 j9 n@}¾¶c«u ¦n§n aO nq§_h¾ejð }n®_j9J c§O}¾ }n¶LĽeð §}9j] Tn}hn®9jł q}n §n} ® §«qjðH\ L9§J qnhnHð jð^ hţ^OhO L9§9 ce9 _»cn®9§u - qţ®nLjðh ©K q}n §n}« jOe¶O j9að§ §9cn®n« qÄðhc«J c§O}¾ @´ nq§_h¾ejĽ }n¶LĽe_e9 qţ®nLjð q}n §n}u ¦«Lð^ aO qn«^_§ð a¾L}n®Ĺ T«jcHO ceðċn®Ĺ q}n ÄOe_§Oejn § ¶j¾¶n}jĽjĹ ωen\´u



Obrázek 2.1. ¦}9j Tn}h9HO L9§ Ln ®´æeð L_hOj¶O 9 }n¶LĽeOjð j9L}n®_jn« ® ~- g EPF

Ċe¾jOc E¨F «®¾Lð qÄO jn § ¶9 qn«^_§ð ~- g 9^ ¢£JU t j9 L9§9 O§« ~8 - NN EkFu - ċe¾jc« EUF O «®¾Lð qÄO jn § ¶9 qn«^_§ð ~- g 9^ £¨J¨ t j9 L9§9 O§« NhnK? Eo·F ® jĽhOHcĹh a9¶´HO 9 9^ ¢¢J£ t j9 9«§n} cĹh L9§9 O§« ®O æq9jĽe cĹh a9¶´HOu Ċe¾jOc E£F «®¾Lð q}ţhĽ} qÄO jn §_ £PJ¨ t ¶ LO®ð§_ §O §n®9jłH\ L9§9 O§ţu

2.2 Vícerozměrná lineární regrese

d_jO¾}jð }OX}O O O ® e_§O}9§«ÄO ċ9 §n ®´ c´§«aO qnL ¶c}9§c9h_ d|G rd_jO9} |OX}O _nj Ge9 _»H9§_njs jO@n g - |¤gd| rg«e§_®9}_9§O d_jO9} |OX}O _njsu be9 _»c9HO O q}n] ®¾Lð qnLeO jð^O qnq 9jĹ\n 9eXn}_§h« j9 n@}¾¶c« ©u©J c§O}ł @´e ® ċe¾jc« EooF qn«^_§ł q}n ce9 _»c9H_ OhnHð ¶ n@}¾¶cţJ 9eO e¶O \n ®´«^ð§ _ q}n ce9 _»c9H_ OhnHð ¶ \e9 «u

i Oaq}®O qn§ÄO@«aOhO®´XOjO}n®9§ h9§_H_ ◻u q}n c9^Ln« ¶ _]§ÄðLu ¦9§n h9§_HO n@ 9\«aO ®O en«qHðH\ ®Oc§n}´ §}Ĺjn®9HðH\ L9§J c§O}Ĺ a n« e_jO¾}jĽ jO¶¾®_ eĹu pn§Ĺ qnLeO @nL« ©u ¶ qnq_ « 9eXn}_§h« ®´qnċð§¾hO ®Oc§n} q9}9hO§}ţ ¨u q}n c9^Ln« ¶O §ÄðLu K¾eO qnċð§¾hO e_jO¾}jð cnh@_j9H_ ®Oc§n}ţ §}Ĺjn®9HðH\ L9§ ®Oc§n}Oh q9}9hO§}ţJ §ðh ¶ð c¾hO q}OL_cHO

„(T`Q F ^/Qm iüQ/mX L FQM2+ pvTQÍQi€K2 px/€H2MQ(„M B M2xM€Kû?
Q/ T`2/B„(K+22xM€Kw Q#`€x2F TQiû FH bB}FmD2K2 /Q iüQ/v- D2DQ^

I–ãŠ ¡Ãë`ëH;Q`BiKmb HBM2€`MQ `2;`2b2 (

ÌH€M2)Fm(p€/Q Tü2bMQbi K2iQ/v FH bB}F +2 TQKQ+Q HBM2€`MQ
e3-N W M / i b2im a o11X8)obÍ2HmM€/Q(Tü2bMQbi x TQm^BiQ HBM2€
p T`iKÿ`m ^ d8-N W M / i b2im 1KQ." ^ 3k-9 W M miQ`bFûK /
T MÿHbFûK D xv+2X

ë`ì C¡óãÓÌÓ ¢ç¶î¤

L2m`QMQpû bQiÿ DbQm T`Qbiü2/F2K T`Q `2 HBx +B ?Hm#QFû?Q mÍ
DQpû?Q mÍ2MQX >Hm#QFû mÍ2MQ b2 x KÿümD2 M xT` +Qp€MQ `2T
p`bip€+?- F/v F ^/€ x p`bi2p i` Mb7Q`KmD2 / i M bKvbHmTHMÿD Q
L2m`QMQp€ bQ# b2 bFH€/€ x p`bi2p M2m`QMi- F/v F ^/w x M2m`QM
xT` +Qp€p€ BM7Q`K +2 M bpûK pbimTm UbF`x2 M i`ûMQp Mû T ` K
TQiû Tü2/€ M bpiD pwbimT- F/2 bB BM7Q`K +B Tü2#2`Qm M2m`QMv
m`ÍBiû bFmTBMv M2m`QMi p bQiB Kiˆ2 x TüQÍBMBi FiBp +B DBMw+
+Qˆ Kiˆ2 TüBTQKQM i +?Qp€MQ #BQHQ;B+Fw+? M2m`QMiX Sü2biQˆ
M2m`QMQpw+? bQiQ b2 BMbTB`Qp Hv p b pÍQK KQxFm- M22tBbim
BKTH2K2MimD2 D FwFQHBp TQ/Q#Mw H;Q`BiKmb- D Fw pvmˆQp€
bQiÿ b2 M2KQ/2HmDQ TQ/H2 kHB/bFû?Q KQxFmX (
L2m`QMQpû bQiÿ Kiˆ2K2 `Qx/ÿHBi M MÿFQHBF F i2;Q`BQ TQ/H2
p bQiB px€D2KMÿ T`QTQD2Mv- TüQT /Mÿ D F b KQiMû M2m`QMv p
9HQ?m `QxTQxM€p€MQ 2KQ+Q x ?H bm b2 TQmˆQp DQ/p /`m?v bQi
UFQMpQHmÍMQV- TüQT /Mÿ FQK#BM +2 Q#Qm /pQmX

I–ãŠ ¡Ãë`à+?ûK `2Fm`2MiMQ bQiÿ I–ãŠ ¡Ãë`á+?ûK /QTü2/Mû bQiÿ

_2Fm`2MiMQ bQiÿ K DQ +vFHB+Fû T`QTQD2MQ M2m`QMi p `€K+
xQ`MÿMQ M Q#X;hxFQ bQiÿ b2 ?Q/Q T`Q xT` +Qp€MQ b2Fp2MÍMQ+
/ûHFQm- D FQ D2 i2ti M2#Q xpmFX GQM;@a?Q`i h2`K J2KQ`v UGah

`2Fm`2MiMQ p`bipv- Fi2`€ /QF€ˆ2 pv?H2/ i xT` +Qp i x€pBbHQbiB
pvbFvimDQ /HQm?Q/Q#ÿ p Í b2X GahJ bQiÿ biQDQ x p2HFwK 9bTÿ
iB+Fû?Q Tü2FH /m i2tim M2#Q p Q#H bRB Tü2pQ/m ü2ÍB M i2tiX (
EQMpQHmÍMQ M2m`QMQpû bQiÿ Dbk9X QTü2/iB ü2Fmÿ 2MQ#`€K2/Q (
F€ˆQ M QT F xT` +Qp i HQF€HMQ FQMi2ti- Fi2`w b2 pvbFvimD2 p2 p
pxQ`Fm- D FQ DbQm M TüQFH / pxQ`v p Q#`€xFmX aQ# T` +mD2 TQ
/ iv- M2/QF€ˆ2 xT` +Qp i b2Fp2M+2 @ bi `€ / i - Fi2`€ T`Q H bQiQ
/ i- Fi2`€ TüB H MQpÿ M D2DQ pbimTX EQMpQHmÍMQ bQiÿ /Qb€?H
bi`QDQpû?Q pB/ÿMQ- D FQ D2 /2i2F+2 Q#D2Fii M2#jQ ÿ D2DB+? FH b
miQüB ÍHje MTFQmp(2/HB 2tT2`BK2Miv b / i b2i2K a o11 B M M2m`QM
SüB i2biQp€MQ `2Fm`2MiMQ M2m`QMQpû bQiÿ /Qb€?HB Tü2bMQbi
HmÍMQ M2m`QMQpû bQiÿ p F /Qb€?HB Tü2bMQbi8 mp€/Qÿ`m ˆ 3j-
miQüB TüB TQmˆBiQ `2Fm`2MiMQ M2m`QMQpû bQiÿ Tü2bMQbi ˆ e
(Ry ˆ Ny W M miQ`bFûK / i b2im p2 T MÿHbFûK D xv+2X
w mp2/2Mw+? ÍH€MFi- Fi2`û b`QpM€p DQ D2/MQiHBpû K2iQ/v FH
M2DH2T Q+? pwbH2/Fi /Qb ?mDQ T`€pÿ M2m`QMQpû bQiÿX _Qx/QH
iQK `2Fm`2MiMQ bQiÿ TQmˆBiQK FQMpQHmÍMQ bQiÿ D2 KBMBK€H
x/€- ˆ2 FQMpQHmÍMQ bQiÿ /Qb ?mDQ KQ`Mÿ H2T Q+? pwbH2/FiX S
bimTm xpQHBH K2iQ/m FQMpQHmÍMQ+? M2m`QMQpw+? bQiQ- Fi2`
F TBiQH2X

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C¡ó ã Ó Ì Ó ¢ ç ¶ î ¤

L2m`QMQp€ bQ# D2 KQ/2H bHQˆ2Mw x MÿFQHBF px€D2KMÿ FQKT
T`QTQD2Mû x b2#QmX hviQ p`bipv Kiˆ2K2 bFH€/ i x b2#2 Q#/Q#Mÿ
p i FQbiFv G1: X E ˆ/€ x iÿ+?iQ p`bi2p i` Mb7Q`KmD2 / i M bKvbHm
i +B / iX ÌQK ?HQm#ÿDB TQxQ`mD2K2 / i p bQiB- iQK pQ+2 b2 HB
iQK pQ+2 BM7Q`KmDQ Q pwbH2/Fm- `2bTX ü2 2MQ / Mû 9HQ?vX
L Q#`€xjFXmRKiˆ2K2 pB/ÿi KQ/2H M2m`QMQpû bQiÿ- Fi2`€ b2 bFH€/
L pbimTm KQ/2Hm D2 Q#`€x2F- M Fi2`ûK D2 M Tb M€ ÍQbHB+2 9
Q#`€x2F xT` +mD2X . i - Fi2`€ x p`bipv pvbimTmDQ DbQm DBbiwK
BM7Q`K +2- Fi2`û M2DbQm /iH2ˆBiû T`Q FQM2ÍMû `QxTQxM€MQ ÍQ
Q#`€xFmX EQMF`ûiMÿ M `2T`2x2Mi +B / i- Fi2`€ pvbimTmDQ x T`
b2 x/i` xMBHv M TüQFH / ?` Mv ÍQbHB+2 9X h iQ / i T`QD/Qm /Q M
_2T`2x2Mi +2 TQbH2/MQ Íip`iû p`bipv mˆ D2 TQˆ /Qp Mw pwbH2/2F
pwbimTm Ry T`QKÿMMw+?- D2DB+?ˆ FiBp +2 xM ÍQ ÍQbHB+B- Fi2`€
D2 xM€xQ`MÿM FiBp +2 m 9- +Qˆ xM ÍQ- ˆ2 bQ# bT`€pMÿ `QxTQx
Q#`€xFmX

I–ãŠ ¡Ã ì`êQ/2H M2m`QMQpû bQiÿ xQ#` xmDQ+Q ÍQbHQpFm 9 M pbimTm
`2T`2x2Mi +2 / i p D2/MQiHBpw+? p`bip€+? pwbimTm RyT`QTQbH2/MQ p`bip

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E ˆ/€ p`bip bQiÿ D2 ipQü2M M2m`QMv- +Qˆ DbQm D2/MQ/m+?û x€F
bQiQ- Fi2`û xT` +Qp€p DQ /QHÍQ BM7Q`K +2X aQH M2m`QMQpw+?
iÿ+?iQ M2m`QMiX JMQ?û TQmˆQp Mû T`BM+BTv p bQiQ+? Hx2 H2
M2m`QMmX

JQiBp +Q T`Q pvipQü2MQ K i2K iB+Fû?Q KQ/2Hm M2m`QMm #vH
;B+Fw M2m`QMX hviQ M2m`QMv ipQüQ M2`pQpQm bQmbi pm M TüX
M2m`QM pvT /€- D2jX Q# H€x/Fm b2 x2 iü2+? ?H pMQ+? Í€biQ @ /2M/
tQMmX

I–ãŠ ¡Ã ì`Ù€F`2b #mšFv M2m`QMm

S`Q pvipQü2MQ K i2K iB+Fû?Q KQ/2Hm M2m`QMm DbQm /iH2^Biû
.2/`Biv DbQm bTQD2Mv ixpX bvM Tb2KB b Qbi iMQKB M2m`QMvX a
/2M/`Biv D2 bp€/ÿM /Q iÿH M2m`QMmX o iÿH2 M2m`QMm b2 M +?€
pv?Q/MQiQ TüQ+?QxQ BM7Q`K +2X ov?Q/MQ+2MQ Q/TQpQ/€ DB
FiBp +2 b2 T F QüQ bF`x2 tQM /Q / H Q+? M2m`QMiX
SüB TQ?H2/m M D2/2M M2m`QM Hx2 i2/v TQp ^Qp i /2M/`Biv x pb
K iB+FQm 7mMF+BX tQM2K b2 QüQ pwbH2/2F K i2K iB+Fû 7mMF-
Fi2`û DbQm M TQD2Mv M tQM€HMQ x FQMÍ2MQX
L Q#`€xjXjb2 M +?€xQ b+?ûK K i2K iB+Fû?Q KQ/2Hm M2m`QMmX
p2FiQ`m pbimTi UM2#Q i Fû pbãX EM Qw+? TüQ?xQ pbimTi D2 pvM€bQ#
TüQbHm MQxm p€?vQTüB bmxmDQ pbimTiK `ixMQm /iH2^BiQbiX SQFm/
M2MQ /iH2^Biw T`Q `Qx?Q/Qp€MQ M2m`QMm-T F D2 p€? iQ?QiQ pb
o€^2Mû pbimTv DbQm T F b2Íi2MvX owbH2/2F bmKv T |FX pbimTmD2
>Q/MQiv FiBp ÍMQ 7mMF+2 Q/TQpQ/ DQ FiBp +B / M(X?Q M2m`QM
h2M T F Ki^2 #wi Tü2/€M /Q / H Q p`bipv M2m`QMQpû bQiÿX

I–ãŠ ¡Ã ì`Ù i2K iB+Fw KQ/2H M2m`QMm

S ` K2i`2K-Fi2`wK M2m`QMQpQm bQ# mÍQK2-DbQm T`€pÿ xKQMÿ
i`ûMQp€MQ bQiÿ D2 M DQi i FQpQm FQK#BM +B p 2+? p ?-Fi2`€ M€
T`2/BF+BX #v+?QK KQ?HB KÿüBi Fp HBim pwbH2/Fm-Fi2`w D2 M
x pûbi ixpX xi`€iQpQm 7mMF+B UHQbb 7mM+iBQMVX obimT2K xi`€iQ
MQpû bQiÿ TQ^ /Qp Mw pwbH2/2F-Fi2`w TQ bQiB +?+2K2X owbimT
bF¦`2-Fi2`û `2T`2x2MimD2-D F KQ+ D2 T`2/BF+2 px/€H2M Q/ bT`€
wi`€iQpû bF¦`2 bB i Fû Ki^2K2 Tü2/bi pBi D FQ DBbiQm T2M HBx +
U T iMQmV T`2/BF+BX SQFm/ xKÿMQK2 p€?v-m/ÿH€K2 MQpQm T`2

bQiÿ- Ki^2K2 `Qx?Q/MQmi Q iQK- x/ xKÿM p ? #vH T`QbTÿ M€X C
M2^ Tü2/ xKÿMQm p ?- i F pwbH2/Fv bQiÿ DbQm ?Q` Q- T`QiQ D2 ?
p ?X

C FKBH2 K€K2 M pbimTm bQiÿ MÿD F€ / i - i F D2 xT` +mD2 T`pMQ
pwbH2/Fv / H Q p`bipÿ- i/X L FQM+B bQiÿ K€K2 pvipQü2MQm T`2/B
xi`€im bQiÿX SüB iQKiQ T`Q+2bm T`Q+?€xQ pbimTMQ / i +2HQm bQ
T`QT ; +2X SüB /QTü2/Mû T`QT ; +B bB mFH€/€K2 pwTQÍ2iMQ ;` 7
M / / iv T`QbimTmDQ+QKB bQiQX

S`QiQ^2 xi`€iQp€ 7mMF+2 M #wp€ TQmx2 M2x€TQ`Mw+? ?Q/MQi-
M2DH2T Q M i`ûMQp€MQ bQiÿX S`QiQ Hx2 M i`ûMQp€MQ bQiÿ TQ
T`Q#HûK- F/v ?H2/€K2 KBMBKmK xi`€iQpû 7mMF+2X #v+?QK #vHB
i F- #v+?QK /Qb€?HB K2M Q xi`€iv- KmbQK2 bTQÍQi i ;` /B2Mi xi
M2Dpÿi Q?Q `ibimVX S`Q+2bm pwTQÍim ;` /B2Mim b2 üQF€ xTÿiM
iQK- ^2 D/2K2 p QT ÍMûK bKÿ`m pwTQÍ2iMQ?Q ;` 7m @ p2 bKÿ`m Q
M2m`QMiK D2DB+? p ?€KX SüB TQbimTm pwTQÍ2iMQK ;` 72K bTQÍ
mxHm pwTQÍ2iMQ?Q ;` 7mX hQK xQbF€K2 ;` /B2Mi xi`€iQpû 7mMF
p ?€+? p bQiBX

C2HBFQ^ M2m`QMQpû bQiÿ KQ?Qm KQi KBHBQMv T ` K2i`i- i F M
xi`€iQpû bQiÿ D2 T` FiB+Fv M2KQ^MûX S`QiQ b2 M x Í€iFm i`ûMQp
+B HBxmDQ p€?v M€?Q/MÿX L€bH2/Mÿ b2 T`Qp2/2 /QTü2/M€ xTÿ
iBK HBx€iQ` U H;Q`BiKmb KÿMQ+Q p€?vV xKÿMQ TüQbHm Mÿ p€?v
p QT ÍMûK bKÿ`m ;` /B2MimX hQKiQ F`QF2K b2 TüB#HQ^QK2 F Mÿ
iBKm p T`QbiQ`m p ?X SQiû T`Qp2/2K2 / H Q Bi2` +B mÍ2MQ @ M Íi2
T`QT ; +2- i/X

L Q#`€xjK2 b+?ûK pw 2 TQTb Mw+? T`Q+2biX .Q M2m`QMQpû bQ
pbimTmDQ / i - Fi2`€ DBKB T`QD/QmX owbimT2K x TQbH2/MQ p`bip
T`2/BF+2 pbiQmTQ /Q xi`€iQpû 7mMF+2 bTQH2ÍMÿ b2 bFmi2ÍMwK +
p`€iQ xi`€iQpû bF¦`2X wTÿiMQm T`QT ; +Q b2 bTQÍQi€ ;` /B2Mi
`Qx?Q/M2- D F xKÿMBi p€?vX

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S`Q i`ûMQp€MQ b mÍBi2H2K i2/v TQiü2#mD2K2 MQiQp M€/ i @ p
M ?`€pFv b MQi +Q- Q D FQm 2KQ+B b2 D2/M€X SH iQ x€b / - ˆ2 b
bQiÿ M2QpÿümD2 M i`ûMQp +Q+? / i2+?X aQ# D2 b+?QTM€ bB K2KQ
F/v#v /Q HQ F i2biQp€MQ bQiÿ M i`ûMQp +Q+? / i2+?- Tü2bMQbi bQ
M2ˆ Tü2bMQbi M / i2+?- x2 Fi2`w+? b2 M2mÍBH X S`QiQ +2HQm K
`Qx/ÿHQK2 M i`ûMQp +Q p HB/ ÍMQ / i b2iX L x€FH /ÿ i`ûMQp +Q
bpû p€?v TQKQ+Q p HB/ ÍMQ?Q / i b2im Kiˆ2K2 Qi2biQp i Tü2bMQb
`Qx/ÿHBi p TQKÿ`m 3y,ky p2 T`QbTÿ+? i`ûMQp +Q?Q / i b2imX
S`QiQˆ2 H2 B i`ûMQp +Q / i b2i Q#b ?mD2 Q#`QpbFû KMQˆbipQ /
/Q QT2` ÍMQ T KÿiBX S`QiQ b2 bQ# i`ûMmD2 TQ K Hw+? /€pF€+?
/ i T F Q#b ?mD2 MÿFQHBF /2bQi2F ˆ biQp2F D2/MQiHBpw+? pxQ`
M p2HBFQbiB D2/MQiHBpû?Q pxQ`Fm p2HBFQbiB QT2` ÍMQ T Kÿ
h`ûMQp +Q # i+?2 xQbF€K2 i F- ˆ2 M€?Q/Mÿ x KQ+?€K2 i`ûMQp +Q
M D2/MQiHBpû # i+?2X h`ûMQp€MQ bQiÿ T`Q#Q?€ TQ D2/MQiHBpv
Q/TQpQ/€ KQ/B}F +B p ? T`Q F ˆ/Qm x /QbimTMw+? /€p2FX 1TQ+?
xT` +Qp€MQ p 2+? /QbimTMw+? i`ûMQp +Q+? / iX

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FiBp ÍMQ 7mMF+2 DbQm p K i2K iB+FûK KQ/2Hm M2m`QMm /iH2ˆB
TQÍ2iMQ?Q ;` 7m M2HBM2 `BimX E/v#v+?QK KÿHB pwTQÍ2iMQ ;` 7
M2€`MQ+? QT2` +Q UHBM2€`MQ+? FQK#BM +Q p2FiQ`m p ? b p2Fi
KQ?H M mÍBi TQmx2 HBM2€`MQ i` Mb7Q`K +2 pbimTMQ+? / iX S`Q
D2 p F TüQHB K Hw T`QiB T`QbiQ`m p 2+? KQˆMw+? i` Mb7Q`K +
x p€/QK2 FiBp ÍMQ 7mMF+B- Fi2`€ D2 M2HBM2€`MQX
FiBp ÍMQ 7mMF+2 K DQ `ixMû pH biMQbiB- MÿFi2`û b2 TQmˆQp
p`bip€+? bQiÿ- DBMû b2 TQmˆQp DQ p2 pwbimTMQ p`bipÿX L2DÍ biÿ
DbQm TQTb€Mv p M€bH2/mDQ+QK b2xM Km,

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GBM2€`MQ FiBp ÍMQ 7mMF+2 b2 TQmˆQp€ TQmx2 p2 pwbimTMQ
`2;`2bMQ+? 9HQ?- F/v pwbimT2K D2 MÿD Fû TQˆ /Qp Mû ÍQbHQ
pBiQbiBX C2DQ M2pw?Q/ D2- ˆ2 /2`Bp +2 HBM2€`MQ 7mMF+2 D2
FiBp ÍMQ 7mMF+Q i2/v M2xKÿMQ ;` /B2Mi xi`€iQpû 7mMF+2- T`Qi
pH biMQbiB M Q M2m`QMQpû bQiÿX

I–ãŠ ¡Ãì`î` 7 HBM2€`MQ 7mMF+2

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aB;KQB/ b2 D FQ FiBp ÍMQ 7mMF+2 TQmˆQp€ #ÿˆMÿ m M2m`Q
F/vˆ ü2 QK2 #BM€`MQ FH bB}F +B UTüBü x2MQ F D2/Mû x2 /pQm
b2 TQ?v#mDQ K2xB y R- +Qˆ `2T`2x2MimD2 T` p/ÿTQ/Q#MQbi- ˆ2
/ MûiüQ/vX SüB TQmˆBiQ bB;KQB/v Kiˆ2 pxMBFMQmi T`Q#HûK KBx
/Qbi M2K2 /Q F` DMQ Q#H biB bB;KQB/v- T F b2 QFQHQ ?Q/MQi bB
FQMbi iMQ 7mMF+2 D2DQ /2`Bp +2 b2 #HQˆQ F MmH2X SüB xTÿi
MmHQp€ /2`Bp +2 xTibQ#Q- ˆ2 b2 B ;` /B2Mi xi`€iQpû 7mMF+2 #m
T`QiQ Tü2bi€p€ mÍBiX

I–ãŠ ¡Ã ì`ï` 7 bB;KQB/v

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aQ7iK t D2 xQ#2+MÿM€ bB;KQB/ /Q pQ+2 /BK2MxQX SQmˆQp€ b
FH bB}F +B /Q D2/Mû x pQ+2 M2ˆ /pQm iüQ/X o TQbH2/MQ p`bipÿ D2
K€K2 iüQ/X owbimT F ˆ/û?Q M2m`QMm x TQbH2/MQ p`bipv `2T`2x2
ˆ2 pbimTMQ / i T iüQ T`€pÿ F / Mû iüQ/ÿX aQmÍ2i FiBp +Q p 2+
p`bipv b2 bQ7iK t2K D2 RX C2 DBbiQi - ˆ2 pbimTMQ / i T iüQ /Q D

aQ7iK t T`Q B@iQm iüQ/m x L pvTQÍQi€K2 TQ/H2 M€bH2/mDQ+Q

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h M;2Mb ?vT2`#QHB+Fw b2 TQmˆQp€ Q#/Q#Mÿ D FQ bB;KQB/ X
7mMF+2 D2- ˆ2 pbimTMQ / i p QFQHQ y x?`m# x +?Qp€X L QT F p
/ i M K TmD2 /Q QFQHQ @R M2#Q RX

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_2Gl x M;HB+Fû?Q _2+iB}2/ GBM2 ` lMBi D2 Í biQ TQmˆQp M€ bF`viw+? p`bip€+? M2m`QMQpû bQiÿX ow?Q/ QT`QiB i M;2Miÿ D2 7mMF+2X S`Q FH /Mû pbimTMQ ?Q/MQiv D2 7mMF+2 HBM2€`MQ H2 TQFm//Q FiBp ÍMQ 7mMF+2 pbiQmTQ M2FH /M€ ?Q/MQi -T F M2m`QMm MmHQpwX h FQpwiQ M2m`QM b2 p bQiB +?Qp€ D FQ K` D2HBFQˆ /2`Bp +2 p M2FH /Mû Í€biB _2Gl D2 MmHQp€X

I–ãŠ ¡Ã ì`ñ` 7 _2Gl

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G2 Fv _2Gl D2 Q#/Q# _2Gl- H2 ?Q/MQiv p M2FH /Mû Í€biB DbQm FQ2}+B2Mi2KX .QFv iQKm K€ 7mMF+2 TQ/Q#Mû pH biMQbiB D FQ pvü2 2M T`Q#HûK b pvKQ`€MQK M2m`QMiX

I–ãŠ ¡Ãì`ò` 7G2 Fv_2GI

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wi`€iQp€ 7mMF+2 b2 TQm^Qp€ TüB i`ûMQp€MQ bQiÿ F pv?Q/MQ+
bQiÿ HB Q Q/ bFmi2ÍMû iüQ/v- /Q Fi2`û i`ûMQp +Q / i T iüQX o iû
TQm^Qp Mw+? xi`€iQpw+? 7mMF+QX

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J 1 D2 biü2/MQ #bQHmiMQ +?v# UGR xi`€i VX S`iKÿ`M€ #bQ
TQm^Qp€ T`Q `2;`2bMQ 9HQ?vX J 1 T`Q FH bB}F +B /Q L iüQ/ D2

J 1 —](7 „H(
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E/2(„ D2 MQiQp M€ ?Q/MQ„H(D2 bTi`2TBmF+2X

B¡‰Ì]âó‰ã¡• ããÓãIB] m

C2 i Fû xM€K€ TQ/ M€xp2K biü2/MQ Fp /` iB+F€ +?v# UGk xi`
bi2DMÿ D FQ J 1- H2 QT`QiB MQ D2 p2HKB +BiHBp€ M QmiHB
TQ^ /Qp MûiüQ/v Q/ T`2/BF+2X w€`Qp2š D2 Ja1 KûMÿ pwTQÍ2iMÿ
Ja1 D2 /2}MQp€M pxi ?2K,

Ja1 — (7 „H(
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E/2(„ D2 MQiQp M€ ?Q/MQ„H(D2 bTi`2TBmF+2X

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1Mi`QTB2 D2 7vxBF€HMQ p2HBÍBM TQTBbmDQ+Q +? QiBÍMQb
*`Qbb@2Mi`QTv UFüQ^Qp€ 2Mi`QTB2V TQTBbmD2 `Qx/QH K2xB /
`Qx/ÿH2MQKBX JBMBK HBx +2 FüQ^Qpû 2Mi`QTB2 i2/v Q/TQpQ
T` p/ÿTQ/Q#MQbiMQ+? `Qx/ÿH2MQX EüQ^Qp€ 2Mi`QTB2 D2 /2}M

1UT-[7 ' MPH '

E/2 T [DbQm T` p/ÿTQ/Q#MQbiMQ `Qx/ÿH2MQX

o M2m`QMQpw+? bQiQ+? b2 pvm^Qp DQ /p /`m?v xi`€iQpw+? 7
S`pMQK x MB+? D2 #BM€`MQ FüQ^Qp€ 2Mi`QTB2- Fi2`€ b2 mTH i
iüQ/ D2 FQKT iB#BHMQ TQmx2 b2 bB;KQB/Qm D FQ pwbimTMQ

ivT2K D2 F i2;Q`B+F€ FüQˆQp€ 2Mi`QTB2- Fi2`€ D2 FQKT iB#BH
E i2;Q`B+F€ FüQˆQp€ 2Mi`QTB2 b2 pvmˆQp€ TüB FH bB}F +B /Q
iüQ/X E i2;Q`B+F€ FüQˆQp€ 2Mi`QTB2 b2 pvTQÍQi€ TQ/H2 M€bH

G 7 (MPH H(

SüB FH bB}F +B /Q#Lmiüˆ-/TQ2Fm/ pbimTMQ / i M2T iüQ /Q B@iû iü
R- TQFm/ M QT F / i /Q / Mû iüQ2 vT b2/B FD+Q-bQiÿX

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C F Db2K DBˆ xKQMBH- /BK2Mx2 T`QbiQ`m p ? D2 TüQHB p2HF€ M
KBMBKmK M2#Q M HB QTiBK M HviB+FvX wiQ?QiQ /ipQ/m b2 QT
Fim HBx +Q p ? Qpÿü2MQK T`QbTÿ MQbiB D2DB+? Fim HBx +2
K HBx€iQ`X S`Q pvipQü2MQ D2/MQ/m+?û Tü2/bi pv- D F b2 TQ?v
bHQmˆQ QX#RÿxiZF wmF xmD2 ;` 7xi`€iQpû 7mMF+2 p x€pBbHQbiB M
/BK2MxBQM€HMQ p€?vX EüBpFm ;` 7m U?Q/MQiv 7mMF+2V p F p
bTQÍQi iX wM€K2 TQmx2 ?Q/MQim 7mMF+2 T`Q Fim€HMQ M bi p
7mMF+2X

I–ãŠ ¡Ã ì`êˆé` 7xi`€iQpû 7mMF+2 p x€pBbHQbiB M M bi p2MQ p€?v

L€bH2/mDQ+Q QTiBK HBx ÍMQ H;Q`BiKmX DbQm b`QpM€Mv p ÍH€
$ã‰•´¡Ìî•¡ç—¡Ìî
L2DD2/MQ/m Q QTiBK HBx ÍMQ H;Q`BiKmb b2 M xwp€ ;` /B2
bTQÍQp€ p TQbmMm p ? p QT ÍMûK bKÿ`m ;` /B2MimX :` /B2Mi /
T ` K2i` @ H2 `MBM; ` i2X G2 `MBM; ` i2 F€HmD2 p2HBFQbi T
p2HBFQbiB ;` /B2MimX C2biHB^2 â‰ FimT€QHMQ Fm bHBpx2MDQpK2 p€?v,

â‰ Æ â‰7k â‰

E/2k D2 H2 `MBM;D2i2i`€iQp€ 7mMF+2X
L bi p2MQ H2 `MBM; ` i2 D2 F`m+B€HMQX SQFm/ #m/2 H2 `MB
FQMp2`;2M+2 F KBMBKm p2HKjX VRQ L HQ€TUFQ#m€2 2@HB TüQHB p2

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I–ãŠ ¡Ã ì`êJ`Hw H2 `MBM;` i2 I–ãŠ ¡Ã ì`êe2HFw H2 `MBM;` i2

Ki^2 M bi i Qb+BH +2 M / HQF€HMQK KBMBK2K M2#Q 9THMû T
Fi2`û?Q DbK2 b2 #HQX BVKBEÙQK#ÿ€ixQ2?FQ Ki^2 M bi i bBim +2-^2 b2
/Qbi MQm/Q KQbi -F/2 D2;` /B2Mi xi`€iQpû 7mMF+2 iûKÿü MmHQ
/2b+2Mi b2 b iQK M2mKQ pvTQü€/ i M iÿ+?iQ `QpBM€+? M bi p2
b2 H;Q`BiKmb Í biQ TQm^Qp€ T`Q bpQDB D2/MQ/m+?Qbi `v+?
SipQ/MQ ;` /B2Mi /2b+2Mi TQÍQi€ b iQK-^2 xi`€iQpQm 7mMF+
p 2+?M i`ûMQp +Q / i X Ì biQ iQ M2MQ KQ^Mû FpiHB p2HBFQbiB
x2MQbiB QT2` ÍMQ T KÿiBX S`QiQ pxMBFHv /pÿ KQ/B}F +2X S`p
:` /B2Mi .2b+2Mi Ua:.V- Fi2`w Fim HBxmD2 p€?v TüB F ^/ûK T
pxQ`Fm +2HQm bQiQX .QFv iQKm FQMp2`;2M+2 F QTiBKm M2MQ
HûKm / i b2imX .`m?Qm KQ/B}F +Q D2 JBMB@" i+? :` /B2Mi .2b+
FQKT`QKBb K2xB TipQ/MQK H;Q`BiK2K a:.X Fim HBx +2 p ? b
+?Q/m m`ÍBiû?Q KMQ^bipQ / i @ /€pFv- # i+?2X
L Q#`€xjXmD2 xM€xQ`MÿMw k@. T`QbiQ` p ? b p`bi2pMB+2KB x
o€?v K€K2 M bi p2Mû p TQÍ€i2Í2MQK #Q/ÿ BT2FX SQFm/ TQm
/2b+2Mi b Fim HBx +Q p ? TQ T`i+?Q/m p 2+? / i- #m/2K2 F QT
TQ KQ/`û TüQK+2X SQFm/ TQm^BD2K2 a:.- #m/2 FQMp2`;2M+2
+? QiB+F€ @ Í2`p2Mû BTFv xM€xQ`šmDQ Bi2` +2 a:.X w2H2Mü
` +QK JBMB@" i+?2X hvTB+Fv b2 bM ^QK2 xpQHBi +Q M2Dpÿi
FQMp2`;2M+2 #vH +Q M2H2T QX

I–ãŠ ¡Ã ì`êS`Q`QpM€MQ F`QFi QTiBK HBx€iQ`i:` /B2Mi .2b+2Mi UKQ/ü2V-
JBMB@" i+? Ux2H2MÿV TüB ?H2/€MQ QTiBK

BÓË¡ÌîóË

JQK2MimK D2 pvH2T 2MQK ;` /B2Mi /2b+2Mim Q ixpX b2i`p ÍM
pxMBF H;Q`BiKm #vH 7vxBF€HMQ b2i`p ÍMQbiX

L Q#`€xjXRDbQm p€?v xM€xQ`MÿMv F`m?2K- MBFQHBp #Q/2K
Qb2X JQ?HB #v+?QK bB Tü2/bi pBi- ˆ2 i2MiQ F`m? D2 iÿH2bQ- Fi
bKÿ`2K F KBMBKm 7mMF+2X E/v#v i2MiQ F`m? KÿH MÿD FQm ?
p HQF€HMQK KBMBKm /QFv bpû ?v#MQbiB M2x bi pBH Tü2D2
SQFm/ #v p M 2K bpÿiÿ TibQ#BH B Q/TQ`Qp€ bQH - T F #v b2 iÿ
M 2K ;HQ#€HMQK KBMBKmX

S`QiQ b2 p H;Q`BiKm JQK2MimK pvbFvimD2 /`m?w pQHBi2HM
H2 `MBM;` i2V- Fi2`wK D2 b2i`p ÍMQbi UKQK2MimKVX Fim HBx
MQK M Fim€HMQK ;` /B2Mim xi`€iQpû 7mMF+2- H2 i Fû M ?v
/`ˆQ x Tü2/+?QxQ+? Bi2` +QX

JQK2MimK /QF€ˆ2 272FiBpMÿ Tü2FQM€p i TH i2 m KÿHF€ HQ
p2`;2M+2 D2 Q#2+Mÿ `v+?H2D Q b K2M QKB Qb+BH +2KB M2ˆ
•‰ àî´ Ì¶ ‰Å¬Óã´îË

L2pw?Q/ Tü2/+?QxQ+? xKQMÿMw+? QTiBK HBx€iQ`i D2- ˆ2 K
D2DB+? T ` K2i`vX SQFm/ DbQm xpQH2Mv T iMÿ- M2/QD/2 F TQ
A F/vˆ T ` K2i`v xpQHQK2 p?Q/Mÿ- DbQm TQ +2HQm /Q#m QTiBK
ˆ€/Qm+QX SQFm/ b2 #HQˆQK2 F QTiBKm- i F #v+?QK BMimBiBpM
b K2M QK H2 `MBM;` i2KX S`QiQ #vHv pvpBMmiv / TiBpMQ QTi
/ :` /- _JaT`QT M2#Q / K U / TiBp2 JQK2Mi 1biBK iBQMVX o x€
xKÿM€+? xi`€iv TüB Fim HBx +B p ? b Kv KÿMQ bpû T ` K2i`vX
HQbi FQMp2`;2M+2 / TiBpMQ+? QTiBK HBx€iQ`i T` FiB+Fv M2M
M bi p2MQ D2DB+? T ` K2i`iX / TiBpMQ QTiBK HBx€iQ`v p2 pÿ
:` /B2Mi .2b+2Mi M2#Q JQK2MimK- DbQm p F pwTQÍ2iMÿ M€`QÍ

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6mHHv +QMM2+i2/ D2 p`bip - p2 Fi2`û K€ F ˆ/w M2m`QM iQHBF pb
Tü2/+?QxQ p`bipv- TüBÍ2Kˆ M F ˆ/w pwbimT Tü2/+?QxQ p`bipv D2
pbimT M2m`QMmX wD2/MQ/m 2Mÿ Hx2 üQ+B- ˆ2 F ˆ/w M2m`QM D2
Tü2/+?QxQ p`bipvX

6mHHv +QMM2+i2/ p`bip b2 TQmˆQp€ D FQ D2/M x TQbH2/MQ+
ˆ2 QT`QiB FQMpQHmÍMQ p`bipÿ M2mKQ 272FiBpMÿ pv?H2/€p i TüQ
.`m?w /ipQ/ D2 KMQˆbipQ p ?X E/v#v+?QK KÿHB pbimTMQ i2MxQ`
pbimTMQ 7mHHv +QMM2+i2/ p`bip #v Q#b ?Qp H Ryyy M2m`QM
p`bip p bQiB pvipQüQ R8yyyy p ?X h2/v R8yyyy mÍBi2HMw+? T `
KMQ?QX

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EQMpQHmÍMQ p`bip mKQ 272FiBpMÿ M DQi pxQ`v- Fi2`û b2 p2 pb
hviQ pxQ`v DbQm pH biMÿ TüQxM Fv- Fi2`û F¦/mDQ pH biMQbi- T
EQMpQHm+2 b2 TQmˆQp€ D FQ pbimTMQ p`bip TüB FH bB}F +B
FQMpQHmÍMQ pbimTMQ p`bip /2i2FQp i iü2# ?` MvX

EQMpQHmÍMQ p`bip M pbimTMQ / i THBFmD2 /BbF`ûiMQ FQMp
Q#b ?mDQ+Q p€?vX EQMpQHmÍMQ p`bipv KQ?Qm #wi D2/MQ M2#
b ?mDQ m`ÍBiû KMQˆbipQ }Hi`i UD2/MQiHBpw+? F2`M2HiV @ T`Q

ˆ2 T`pMQ }Hi` /2i2FmD2 M TüQFH / pQ/Q`QpMû ?` Mv /`m?w }Hi
E2`M2H K€ m`ÍBiw `QxKÿ` p2 bi2DMû /BK2MxB D FQ pbimTMQ / i X
T //BM; @ /QTHMÿMQ QF` Di / i m`ÍBiQm ?Q/MQiQmX S //BM; b2 p
x +?Qp€MQ `QxKÿ`i pbimTm pwbimTm FQMpQHmÍMQ p`bipvX SQ
bi`B/2- Fi2`w üQF€- Q FQHBF b2 K€ KüQˆF F2`M2Hm TQbQmp iX
P#`€x2XFRm F xmD2- D F T` +mD2 FQMpQHmÍMQ p`bip X JQ/2HQp
#v b2 / H +? ` Fi2`BxQp iD FQ k@. FQMpQHmÍMQ p`bip b D€/`2K
}Hi`2K- #2x T //BM;mX EQMpQHmÍMQ p`bip M2D/üQp pv#2`2 pbim
pQHm+B b F2`M2H2K Up ? KBV pwbH2/2F x TQ 2 M TüQbHm MQ
#v+?QK Tü2/TQFH€/ HB bi`B/2 R- T F #v b2 KQ/`w Íip2`2+ p2 pbim
MmH Q D2/2M bHQmT2+ /QT` p TQbimT #v b2 xQT FQp HX h Fi
FQMpQHmÍMQ p`bipvX

I–ãŠ ¡Ã ì`êŠ`BM+BT xT` +Qp€MQ / i p FQMpQHmÍMQ p`bipÿ

ì`ë`ì B‰ VÓÓÅ

J tSQQHBM;Qp€ p`bip D2 /`m?2K bm#b KTHBM;Qpû Ub/`mˆQp +
M2Q#b ?mD2 ˆ€/Mû mÍQ+Q b2 T ` K2i`v- bHQmˆQ TQmx2 F2 xK2M
/ iX o`bip Q#b ?mD2 D€/`Q- Fi2`û b2 TQ?v#mD2 TQ pbimTMQ+?
FQMpQHmÍMQ D€/`Q p FQMpQHmÍMQ p`bipÿX A x/2 D2 MmiMû M bi
`QxKÿ` D€/` bi`B/2X C€/`Q TQiû x2 pbimTMQ+? TüQxM Fi- Fi2`û
M2Dpÿi Q T`p2FjXURQ8# `€x2F

I–ãŠ ¡Ã ì`êŠ`BM+BT xT` +Qp€MQ / i p J tSQQHBM;Qpû p`bipÿ

.QFv J tSQQHBM;m xK2M QK2 Q#D2K / i p bQiB M€bH2/mDQ+Q
K2M Q KMQˆbipQ mÍQ+Q+? b2 T ` K2i`iX .Q DBbiû KQ`v b2 iQK xH
D2HBFQˆ b2 x ?Q/Q M2/iH2ˆBi€ / i Ux m`ÍBiû Q#H biB b2 pv#2`2 T
bHQpv- D2biHBˆ2 D2 /2i2FQp€M TüQxM F b pvbQFQm ?Q/MQiQm
M€bH2/mDQ+Q J tSQQHBM; x DBbiQ- ˆ2 M2x€H2ˆQ- F/2 Tü2bMÿ p
/2i2FQp€MX

ì`ë`í ãÓàÓóî

.`QTQmi D2 / H Q p`bipQm- Fi2`€ M2Q#b ?mD2 mÍQ+Q b2 T ` K2i`v
iBpmD2 m`ÍBiw TQÍ2i bpw+? pbimTiX JMQˆbipQ xM2?Q/MQ+2Mû BM
p`bipvX *?+2K2@HB xH2T Bi pv?H2/€p€MQ Q#2+Mw+? pxi ?i p2 p
TQmx2 K2KQ`Qp€MQ i`ûMQp +Q+? / i- /`QTQmi F iQKm Kiˆ2 TQKQ
bQiÿ DBbiw /`m? mKmX .QFv iQKm bQ# M2#m/2 iQHBF +BiHBp€ M
/ i2+?X

ì`ë`î ‰î—±CÓãË

" i+?LQ`K p`bip i Fû M2Q#b ?mD2 mÍQ+Q b2 T ` K2i`v- bHQmˆQ F
?Q/MQiv bi M/ `/MQ Q/+?vHFv /€pFv / i p FQMF`ûiMQ Í€biB bQi
MQ`K HBxQp M€ pbimTMQ / i /Qb ?mDQ p M2m`QMQpw+? bQiQ+?
M2MQ`K HBxQp M€X . i TQ T`i+?Q/m Í€biQ bQiÿ p F MQ`K HBx
S`QiQ D2 p?Q/Mû TQmˆQi " i+?LQ`KX LQ`K HBx +2 TQK€?€ F KBx2
;` /B2Mim- iQK T€/2K TQK€?€ B F2 xTÿiMû T`QT ; +B +?v#v /Q ?H

ì`ì VãÓ–Å¢Ë

o Tü2/+?QxQ Í€biB T`€+2 Db2K xKQMBH MÿFi2`û T`Q#HûKv- M Fi2
+?vHMûX S`Q#HûK KBx2MQ ;` /B2Mim x TüQÍBMQ iQ- ˆ2 b2 M2#m/
mHQˆ2Mû ?Hm#QFQ p bQiBX L QT F TüB 2tTHQ/Qp€MQ ;` /B2Mim
/ iQpû?Q ivTm- p2 Fi2`ûK D2 mHQˆ2M€ FiBp +2X owbH2/2F bQiÿ
p i2HMwX oxMBF M2#Q /ibH2/Fv iÿ+?iQ T`Q#HûKi Hx2 pw` xMÿ QK
FiBp ÍMQ+? 7mMF+Q M2#Q " i+?LQ`K2KX

Ep HBim mÍ2MQ bQiÿ Kiˆ2K2 bH2/Qp i MÿFQHBF xTibQ#vX C2/M
MQbiB p x€pBbHQbiB M Í b2 @ `2bTX i`ûMQp +Q 2TQ 2X Sü2bMQb
ˆ2 T`p2F #m/2 FH bB}FQp€M /Q bT`€pMû iüQ/vX .Q ;` 7m b2 F`2bH
i`ûMQp +Q+? p HB/ ÍMQ+? / iX SQ/H2 px€D2KMû TQHQ?v iÿ+?iQ
MQmi- D F T`Q#Q?€ mÍ2MQX *QH2K D2 /Qb€?MQmi +Q M2Dpv Q
i`ûMQp +Q+? / i2+?X

C2biHBˆ2 /Qb ?mD2K2 pvbQFû Tü2bMQbiB M i`ûMQp +Q+? / i2-
MQ+?- /Q+?€xQ F Tü2mÍ2MQ bQiÿ UQp2`}iiBM;mVX E D2pm TüBbT
b€?H€ `+?Bi2Fim` bQiÿ M2#Q TüQHB /HQm?€/Q# mÍ2MQX #v+?
Kiˆ2K2 TüB/ i .`QTQmi- TüQT /Mÿ J tSQQH p`bipv- xK2M Bi M2m`
/Q#m i`ûMQp€MQ bQiÿ M2#Q `Qx QüBi / i b2iX . i b2i D2 KQˆMû `
K2Mi +Q / i b2imX

C2biHBˆ2 /Qb ?mD2K2 MQxFû Tü2bMQbiB M p HB/ ÍMQ+? B i`û
M2/QmÍ2MQ bQiÿ UmM/2`}iiBM;VX `+?Bi2Fim` D2 TüQHB KÿHF
#HûKm M2#Q i`ûMQp HB DbK2 bQ# F`€iFQm /Q#mX aQ# M2MQ b+?
pbimTMQ+? / i2+? Í biQ M27mM;mD2 MB M i`ûMQp +QK / i b2im

I–ãŠ ¡Ã ì`êï` 7 Tü2bMQbiB p x€pBbHQbiB M TQÍim 2TQ+? xM€xQ`šmDQ+Q
Qp2`}iiBM;m /ÿHQ+Q Í€`v- F/v D2 M2DH2T Q Tü2`m Bi mÍ2M

. H Q T`Q#HûK- b2 Fi2`wK b2 Kiˆ2K2 TQiwF i- D2 M2pvp€ˆ2Mw /
bB- ˆ2 #v+?QK FH bB}FQp HB /Q /pQm iüQ/ "X o i`ûMQp +QK / i
TQÍ2i pxQ`Fi iüQ/v " p TQKÿ`m R,RyX aQ# #v b2 M mÍBH FH bB
iüQ/v "- M2x€pBbH2 M pbimTMQ+? / i2+?- D2HBFQˆ FH bB}F +2 /Q
/Q#MÿD Q- QT`QiB TüBü x2MQ pbimTm /Q iüQ/v X h2MiQ T`Q#HûK
xTibQ#vX C2/MQK xTibQ#2K D2 x ?`MmiQ / i x KBMQ`BiMÿ x biQm
D2/Mû 2TQ 2- i F #v b2 TQÍiv pxQ`Fi D2/MQiHBpw+? iüQ/ p D2/Mû
?wK xTibQ#2K- Fi2`w #vH TQmˆBi p iûiQ T`€+B- D2 TQKÿ`Qpû `Qxp
7mMF+2 T`Q D2/MQiHBpû iüQ/vX o mp2/2MûK TüQFH /m #v+?QK ?
T`Q iüQ/m xpÿi BHB Ryt ?Q/MQim xi`€iQpû 7mMF+2 T`Q iüQ/m "
P#2+Mÿ b2 bM ˆQK2 /Qb€?MQmi +Q M2DH2T Q ;2M2` HBx +2 T
M2DKûMÿ K2KQ`Qp H TüQxM Fv pvbFvimDQ+Q b2 p i`ûMQp +Q+?
M mÍBH Q#2+Mû bTQDBiQbiB p TüQxM +Q+?- Fi2`û p2/Qm F2 bT`€
M2KmbQ #wi /Q#ü2 T i`M€ MB x ;` 7m Tü2bMQbiB FH bB}F +2X L T
2KQ+Q b2 bQ# /Q DBbiû KQ`v mÍQ +2Hû pÿiv- MBFQHBp TQmx2 2KQ
bQiÿ H2T Q M pÿi€+? pvbFvimDQ+Q+? b2 p / i b2im- M2ˆ M pÿi€
Q#b ˆ2Mv M2#vHvX

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m;K2Mi +2 D2 mKÿHû `Qx Qü2MQ / i b2im- x 9Í2H2K Tü2/2DBiQ
p +Q+? / i2+?X S`Q Tü2/bi pm mp2/m TüQFH / M2m`QMQpû bQiÿ-
Q#`€xFiX SQFm/ b2 bQ# #m/2 mÍBi TQmx2 M / i2+? Í2`p2Mw+? mi
x2xM€p i mi DBMw+? # `2pX #v+?QK `Qx QüBHB / i b2i- M2TQiü
7QiQ;` }2 miX ai ÍQ M€ / i b2i`Qx QüBiQ iv b Kû Q#`€xFv- Fi2`û
`pvX

SüB m;K2Mi +B M2bKQ /QDQi F2 xi`€iÿ BM7Q`K +2- Fi2`€ D2 FH
F2 xKÿMÿ iüQ/v- /Q Fi2`û / i FH bB}FmD2K2X o TüQFH /m b miv b
M2xKÿMBH Q#D2Fi M Q#`€xFm- bi2DMÿ i F D2 ÍHQpÿF b+?QTMw `
miQX S`QiQ Hx2 i FQpQm m;K2Mi +B TQmˆQiX

m;K2Mi +B xpmFQpw+?M ?`€p2F Hx2`2 HBxQp iD2DB+?x mK
bmM2K M ?`€pFv p2 7`2Fp2MÍMQ Q#H biB M2#Q TQbmM2K M ?`€p
TQbmMm pÍ bQpû Q#H biB b2x Í€i2F M ?`€pFv TQbmM2 pxMBFH
bi2DMû M ?`€pFv UQT2` +2`QHH @TQ/Q#Mÿ D FQ#v M ?`€pF #v
TQQiQÍBÿHBVX (