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POTENTIAL OF A.I. : FORECASTING THE REPRODUCTION NUMBER OF COVID-19 USING NEURAL NETWORK

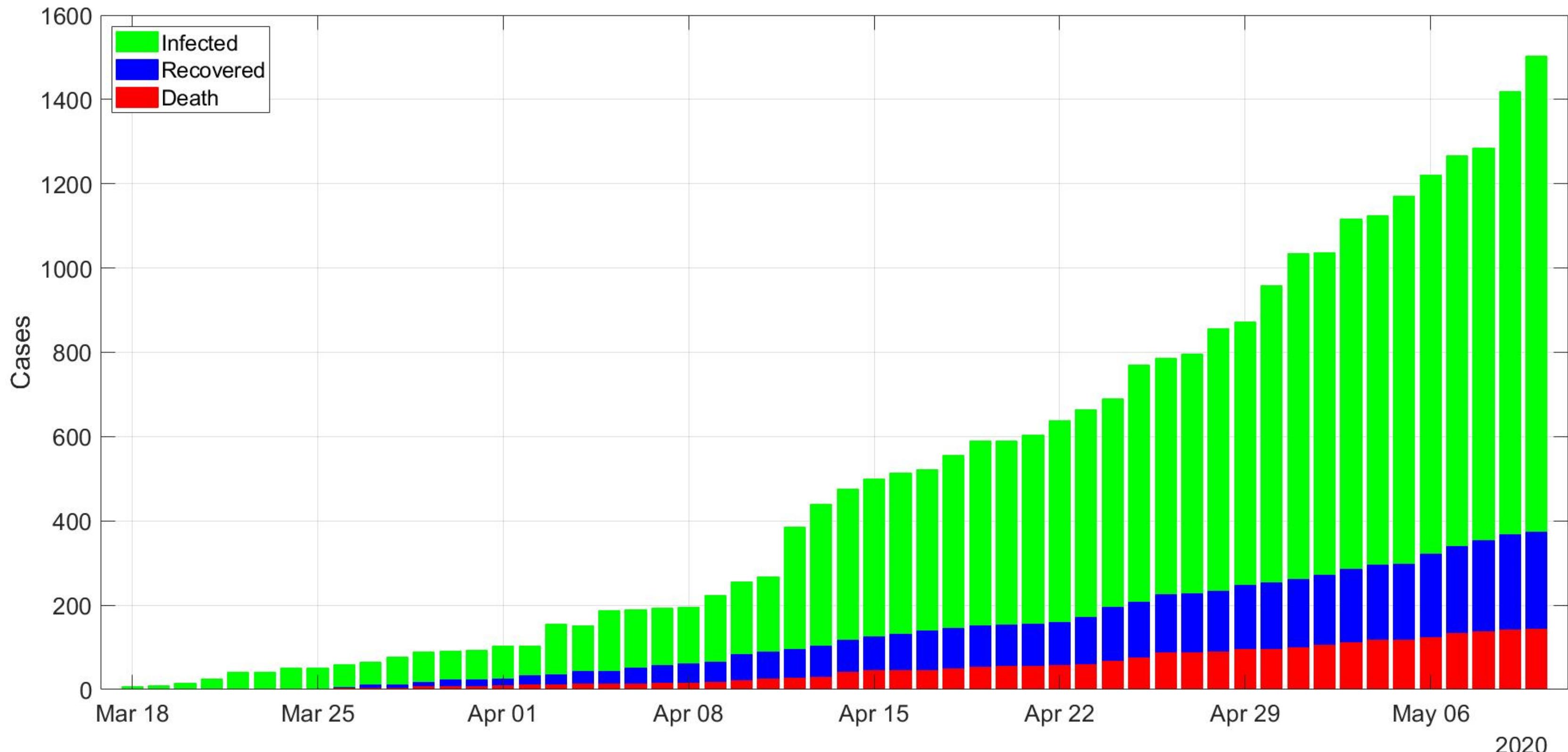
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DIDUKUNG OLEH:

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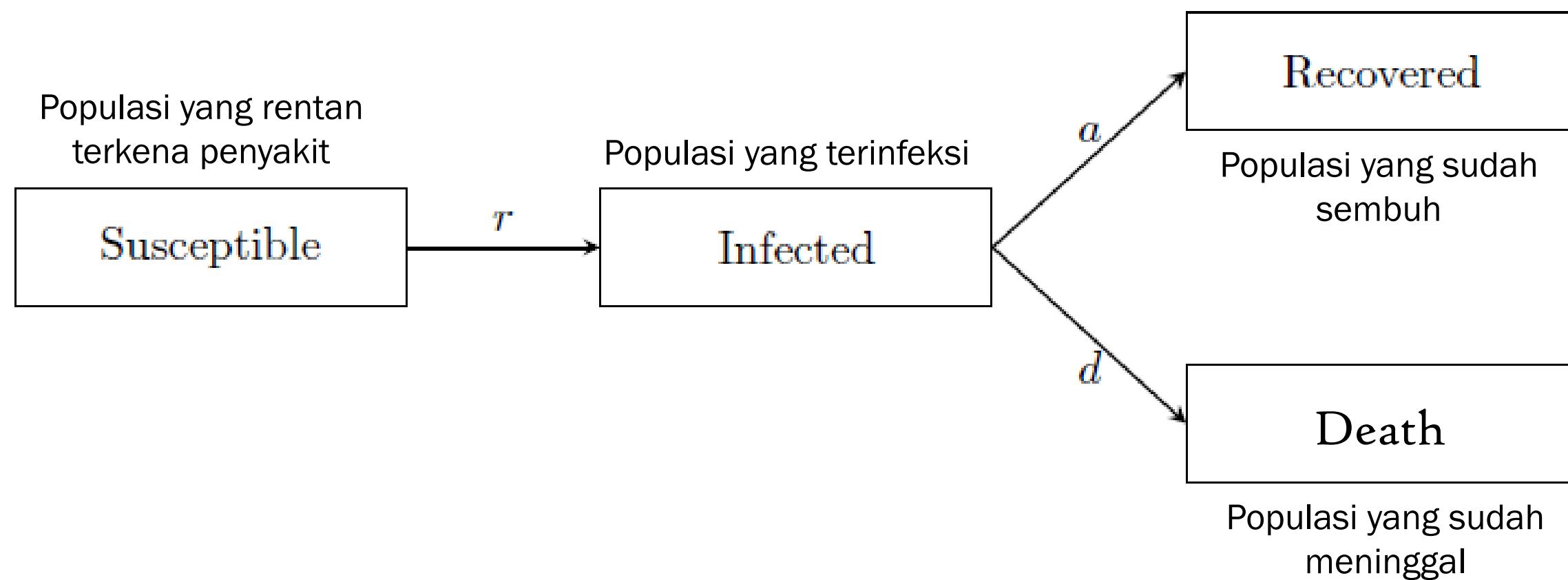
DATA PLOT EAST JAVA CASES

18 MARET 2020 – 10 MEI 2020



MODEL SIRD - EAST JAVA

SUSCEPTIBLE – INFECTED – RECOVERED – DEATH



$$\frac{dS}{dt} = -rSI$$

$$\frac{dI}{dt} = rSI - (a + d)I$$

$$\frac{dR}{dt} = aI$$

$$\frac{dD}{dt} = dI$$

$$S(0) = S_0, I(0) = 7,$$

$$R(0) = 0, D(0) = 1$$

1

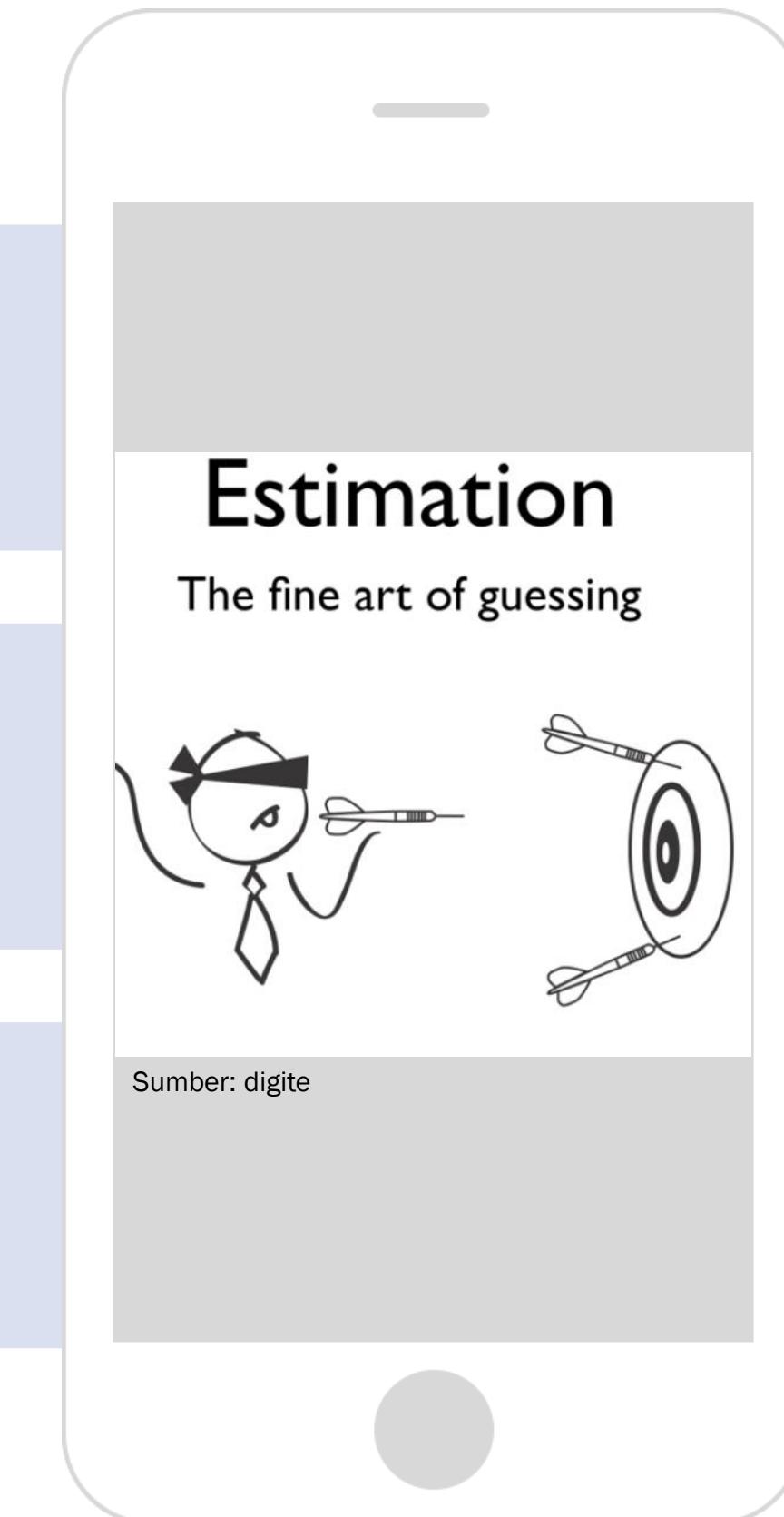
Hyperparameter Optimization
(Evolutionary Algorithm, Brute Force, Grid
Search, Random Search)

2

fminsearch – Fit Function MATLAB

3

lsqfit – Fit Function MATLAB



OTHER METHODS TO ESTIMATE THE PARAMETERS

MATLAB RUNNING EXAMPLES

PARAMETER ESTIMATION USING GENETIC ALGORITHM IN THE SIRD MODEL

(POSSIBILITY: WORST CASE)

FITNESS FUNCTION

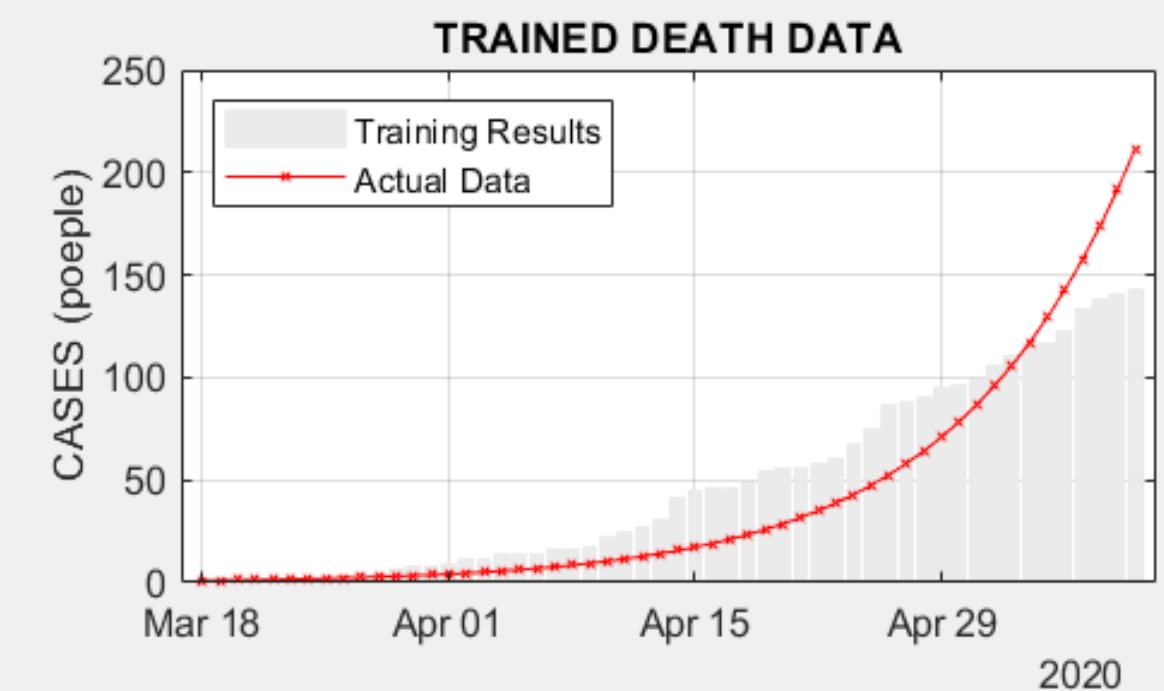
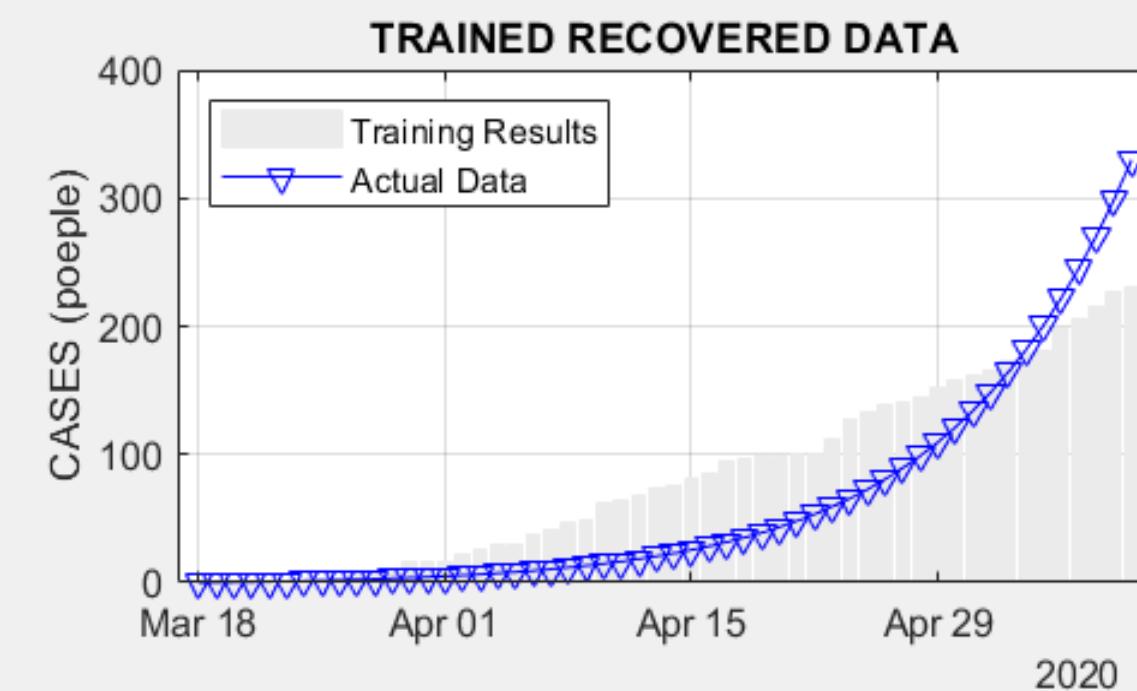
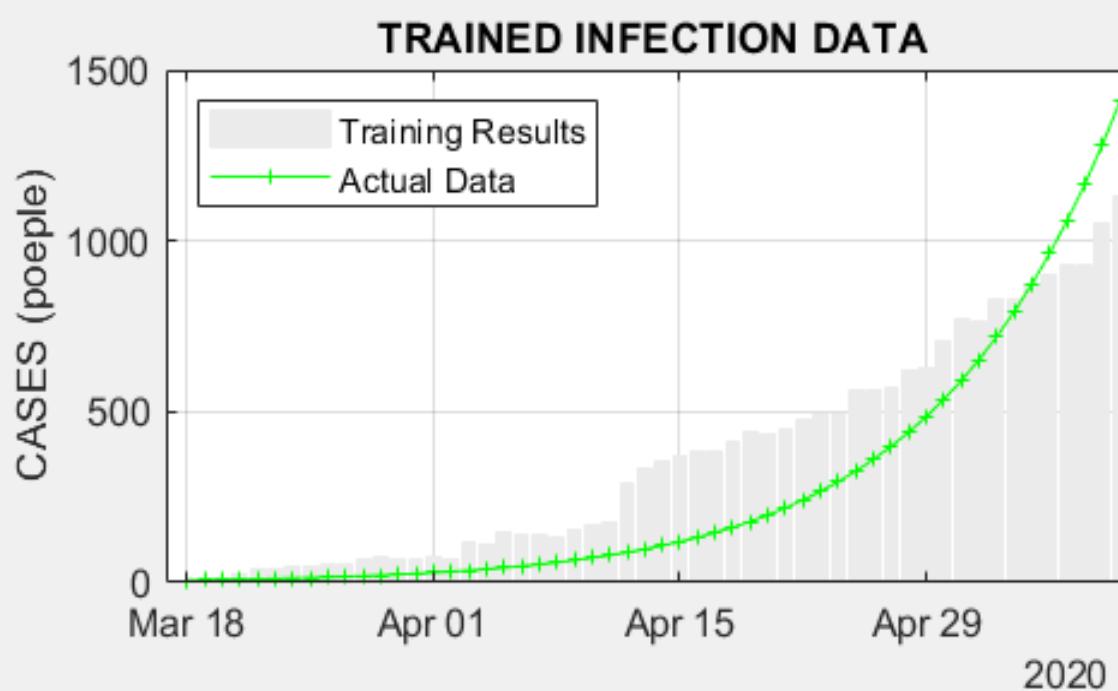
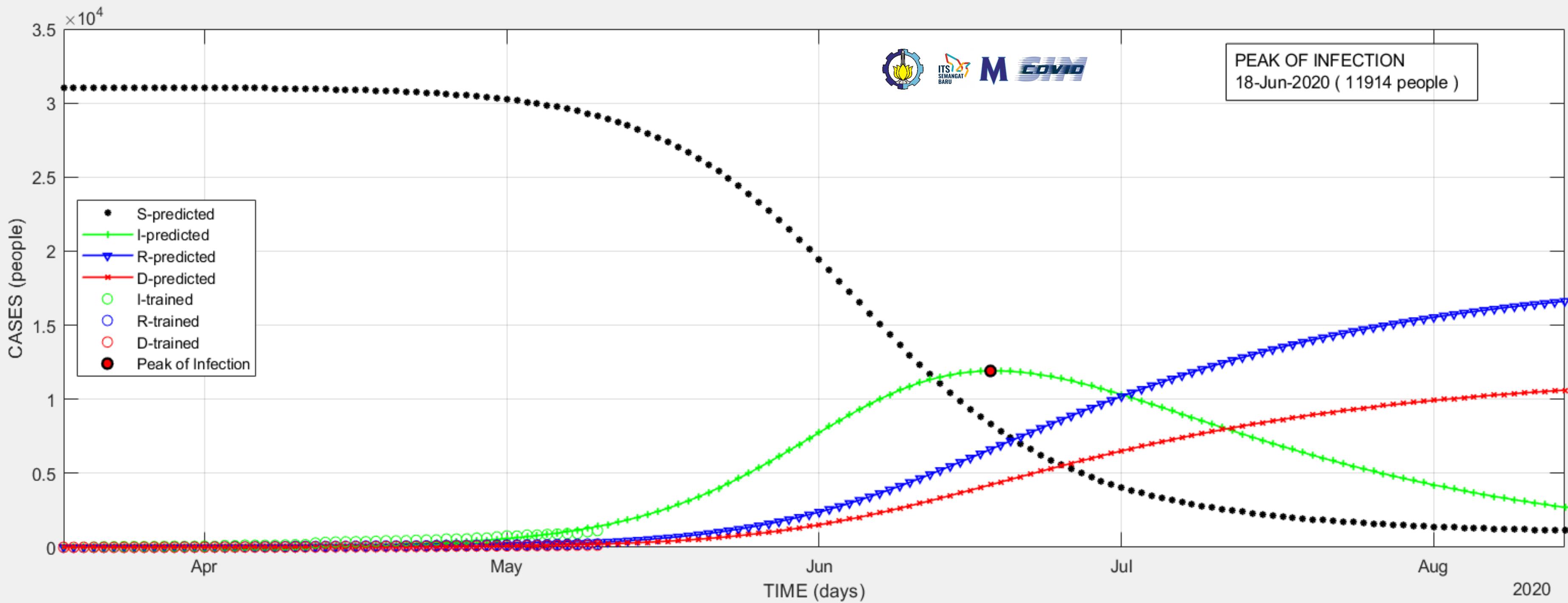
$$\min_{\{S_0, r, a, d\}} RMSE (y, \hat{y})$$

y : data aktual

\hat{y} : data hasil simulasi

S_0	r	a	d	fitness
Command Window				
66853.9859407034	8.13915934609522e-07	0.00804253242717155	0.000103571693438912	156.010036708482
10298.2695735831	1.60152855841021e-05	0.159672506939259	0.135011390404602	162.907166108655
57989.0557879361	1.1627078855437e-06	0.00051358939071799	0.0732280631165222	161.275213602287
53305.6189586265	1.22267212897827e-06	0.178806000318987	0.0407532205272619	164.330712312444
40305.917261178	9.90641484059934e-06	0.164589111435234	0.16632593098457	151.02473732606
71336.3603016656	5.22684270051065e-07	0.00362493265277489	0.00481819275002786	160.757835481888
5614.58141033967	7.34913070561754e-07	0.317148800883181	0.0161469822208128	165.225737500208
49903.632720804	1.38180239300783e-06	0.00118306221317661	0.0577867143254359	159.86013377597
95883.8999919975	1.29141426827382e-06	0.101826924820086	0.0386179946654335	159.275644466153
64243.9747220844	1.03321083233826e-07	0.355371805526428	0.017037604146363	165.2396071408
47159.0005473425	4.0280616587098e-05	0.595487767154903	0.303400234380157	11116.6472292424
62034.8671720616	4.16604681915484e-06	0.483232921947951	0.0217377298952715	163.534818923979
40646.8567891819	1.61130187681151e-06	0.197848440377646	0.112263810769025	164.700517107097
121142.130754471	6.41062254215453e-06	0.744853363212882	0.0627446036271664	146.467432029367
50414.0885139542	3.42025575652441e-06	0.182133609298117	0.0225873373788112	158.857204479547
892.34296858814	5.28295104893046e-05	0.0646296367927709	0.000568287525995015	162.757940576226
41635.9104505307	4.56896862396427e-06	0.031518950044335	0.16354080708032	155.825207835874
11705.2778833074	9.43759544102797e-06	0.0511472360729728	0.00612045484351473	143.982612249277
10622.8059206948	5.76009776401573e-07	0.000512338191452159	0.49491569006599	165.449589259352
24485.0440635147	1.42410673215481e-06	0.199620195586985	0.43443872926989	165.302058366695
62569.8448340638	1.21863994047233e-06	0.00973748696326088	0.000923175669135324	144.653973783703
39398.0775963119	8.91956772464595e-06	0.15099981383901	0.399822056131353	162.738192919187
65579.9488823894	8.60333618798338e-07	0.010097443408681	0.00499979688704927	156.715121991438
13465.93342271	8.65644712045295e-07	0.0191269872646678	0.20621206572165	165.145655537231
62351.6383248353	9.7876005598199e-07	0.264077824058204	0.105685165885699	164.878503830911
50624.1995819492	5.43845170591585e-06	0.197624446149169	0.369358088039906	163.825159271366
29901.3463920592	2.21767412399042e-06	0.00122336201472109	0.0492575320097898	159.437278501237
63725.6683215157	1.16897574300643e-06	0.391597010195304	0.0445672791297994	164.91693783084
76872.6672548181	1.30913806114587e-06	0.593602094187916	0.687559556884169	165.299139880303
74333.165317135	3.98868744045637e-06	0.287884236188905	0.0296904803006393	153.243348957315
117616.963770993	8.37536968858003e-07	0.0419807325510799	0.0587294229052227	159.181338814566
19109.3740026529	6.31529045455121e-06	0.0801624677390296	0.0165806097469999	153.293072536672
85225.7089702942	6.12544373283036e-07	0.749677443892963	0.999545192444453	165.409196745598
16927.4326921936	7.87523731252995e-07	0.000791040686685565	0.0580363213805437	164.493867257644
10872.4492002852	3.21746260435233e-06	0.000227034014255719	0.00267697774979406	160.722412398098
42811.1839209679	7.0704301988928e-06	0.161672874823656	0.223879328613936	159.710678510899
35918.7617591081	2.09530592125618e-06	0.264015158354326	0.205084564961714	164.961850761966
93825.3089709625	5.78321491362636e-06	0.877288264397643	0.00929786999900191	162.986412519804
3910.62514554515	4.61941062837703e-06	0.0407220523284056	0.0090485224943357	164.189514516675
66375.3211919142	9.45393924701669e-07	0.0821699865770504	0.0190002283522153	162.809637929802
10872.4492002852	3.21746260435233e-06	0.000227034014255719	0.00267697774979406	160.722412398098
98427.043718464	1.47323563717018e-06	0.0626097268166618	0.0365547065655152	141.906632242258
87937.0486584197	1.26130176513726e-05	0.923686303902619	0.506823952124006	160.360552471598
101734.734329839	8.45232226947952e-07	0.00592396751916813	0.000116674562218901	130.952400641802
25822.5036317762	2.53854488378403e-07	0.0370815188164903	0.000413418326362497	164.59808527348
111803.10163516	6.52885711323335e-07	0.00419830840617022	0.0832638133941993	161.502445844913
68423.0516721121	3.30002573216319e-07	0.303312393829448	0.0360708648620293	165.112898628239





WHEN WILL THIS PANDEMIC BE OVER?

Mengecek jumlah infeksi?
Kasus Positif Tes Swab?

Setelah PSBB 2-4
minggu? Atau seusai
Lockdown?

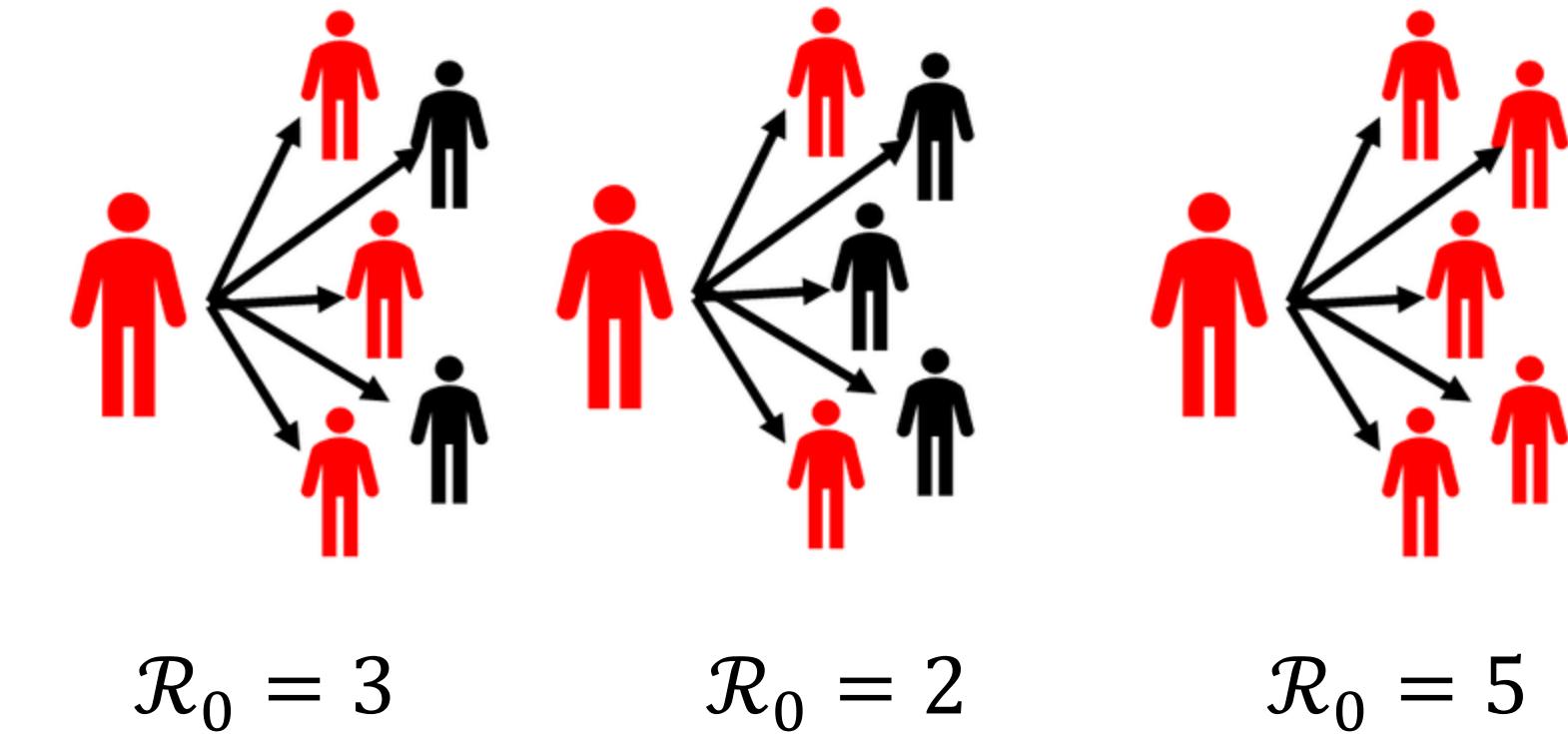
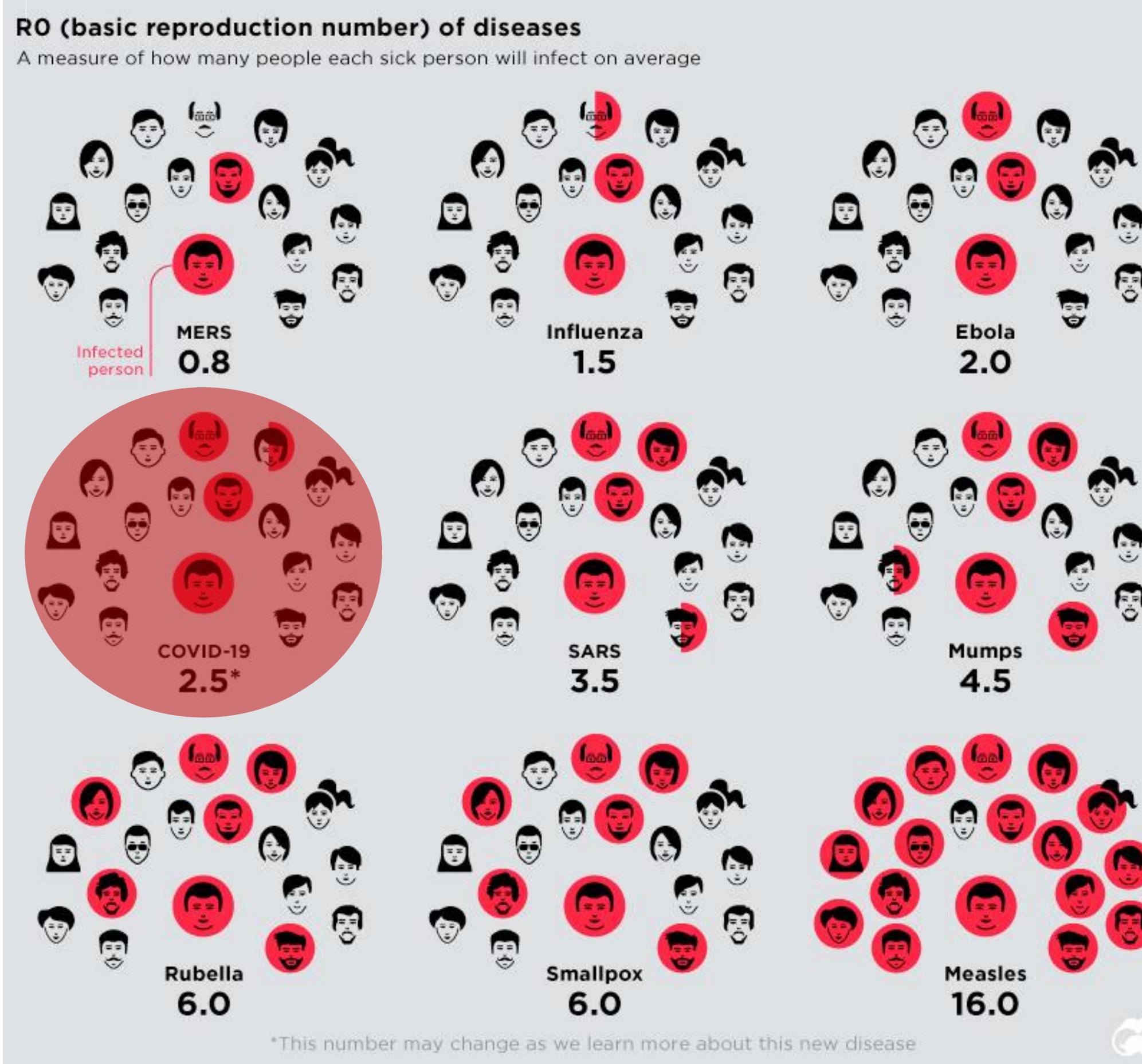


Melihat laju kematian?
atau laju kesembuhan?

Menghitung rasio orang
sembuh dan meninggal?

JAWABAN: TIDAK ADA YANG TAHU DENGAN PASTI.

NAMUN, INDIKASINYA BISA DILIHAT DENGAN MENGGUNAKAN SUATU
UKURAN, YAITU REPRODUCTION NUMBER.



REPRODUCTION NUMBER:

1. Basic : \mathcal{R}_0 (expected value before pandemic spreads)
2. Effective : \mathcal{R}_t (value at specific time)

- Cowling, B. J., Lau, M. S. Y., Ho, L.-M., Chuang, S.-K., Tsang, T., Liu, S.-H., ... Lau, E. H. Y. (2010). The Effective Reproduction Number of Pandemic Influenza. *Epidemiology*, 21(6), 842–846.
- Nishiura, H., & Chowell, G. (2009). The Effective Reproduction Number as a Prelude to Statistical Estimation of Time-Dependent Epidemic Trends. *Mathematical and Statistical Estimation Approaches in Epidemiology*, 103–121.

CALCULATE THE VALUE OF \mathcal{R}_t

- Susanto, H., Tjahjono, V.R., Hasan, A., Kasim, M.F., Nuraini N., Putri, E.R.M., Kusdiantara, R., Kurniawan, H., (2020). How Many Can You Infect? Simple (and Naive) Method of Estimating the Reproduction Number. Working Paper.
- Lai, A., Bergna, A., Acciarri, C., Galli, M., & Zehender, G. (2020). Early Phylogenetic Estimate Of The Effective Reproduction Number Of 2019-nCoV.
- Chong, Y. C. (2020). A Novel Method for the Estimation of a Dynamic Effective Reproduction Number (Dynamic-R) in the CoViD-19 Outbreak.

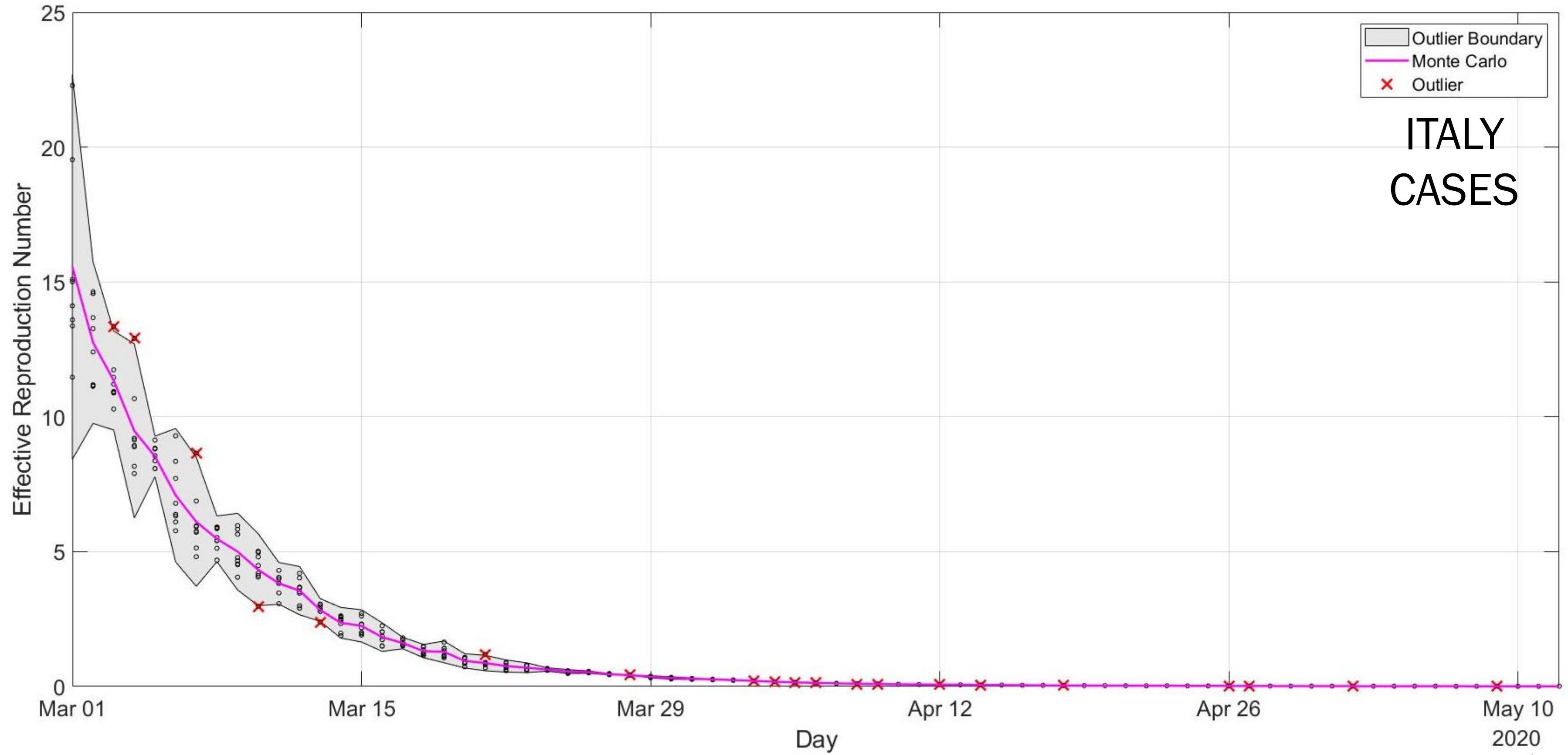
$$\mathcal{R}_t = \left(\frac{S_t}{N} \right) \mathcal{R}_0$$

dimana:

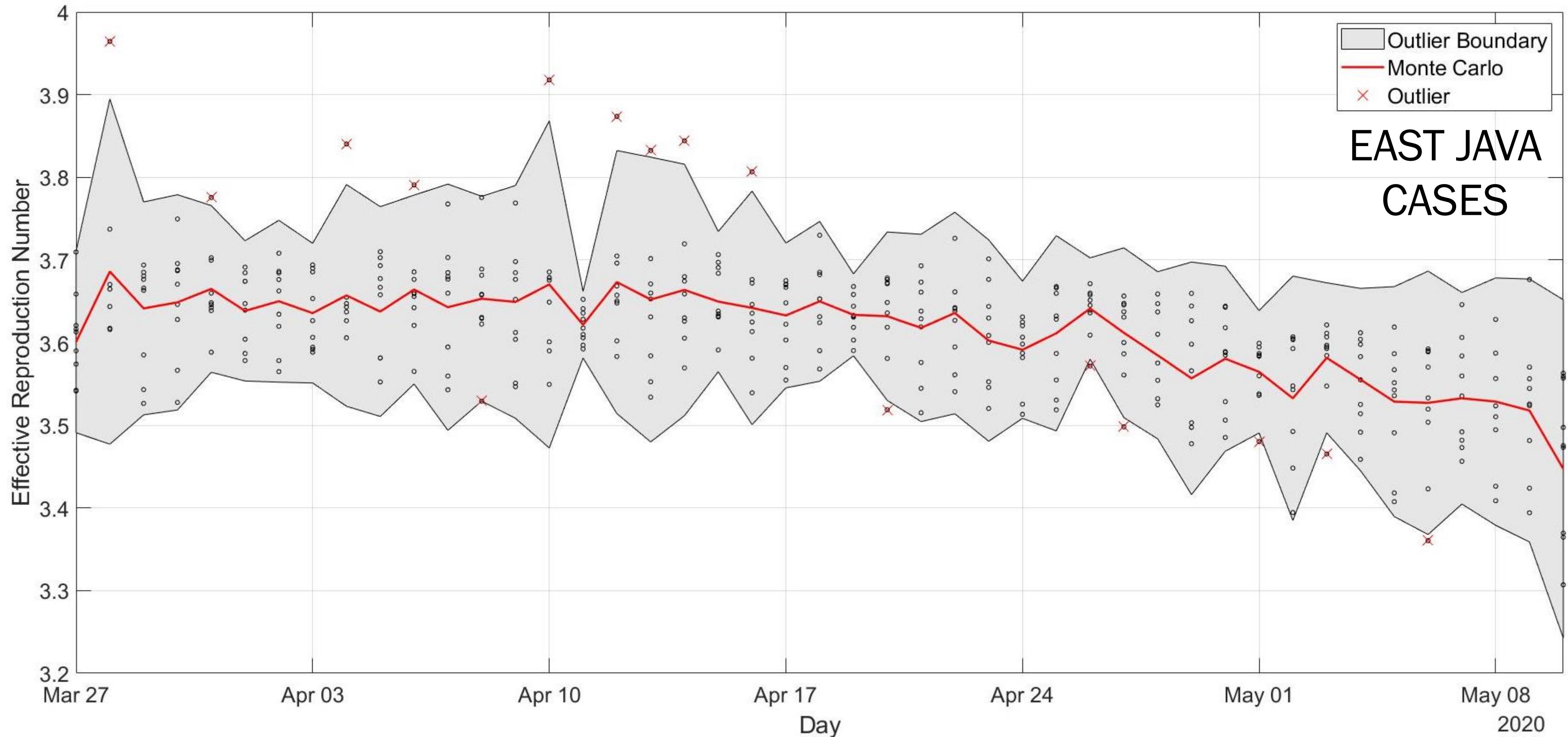
$$\mathcal{R}_0 = S_0 \left(\frac{r}{a+d} \right)$$

$$N = S_0 + I_0 + R_0 + D_0$$

PLOT REPRODUCTION NUMBER \mathcal{R}_t (Early Findings)



PLOT REPRODUCTION NUMBER \mathcal{R}_t (Early Findings)



DESIGNING LSTM NETWORK (MATLAB R2019b)

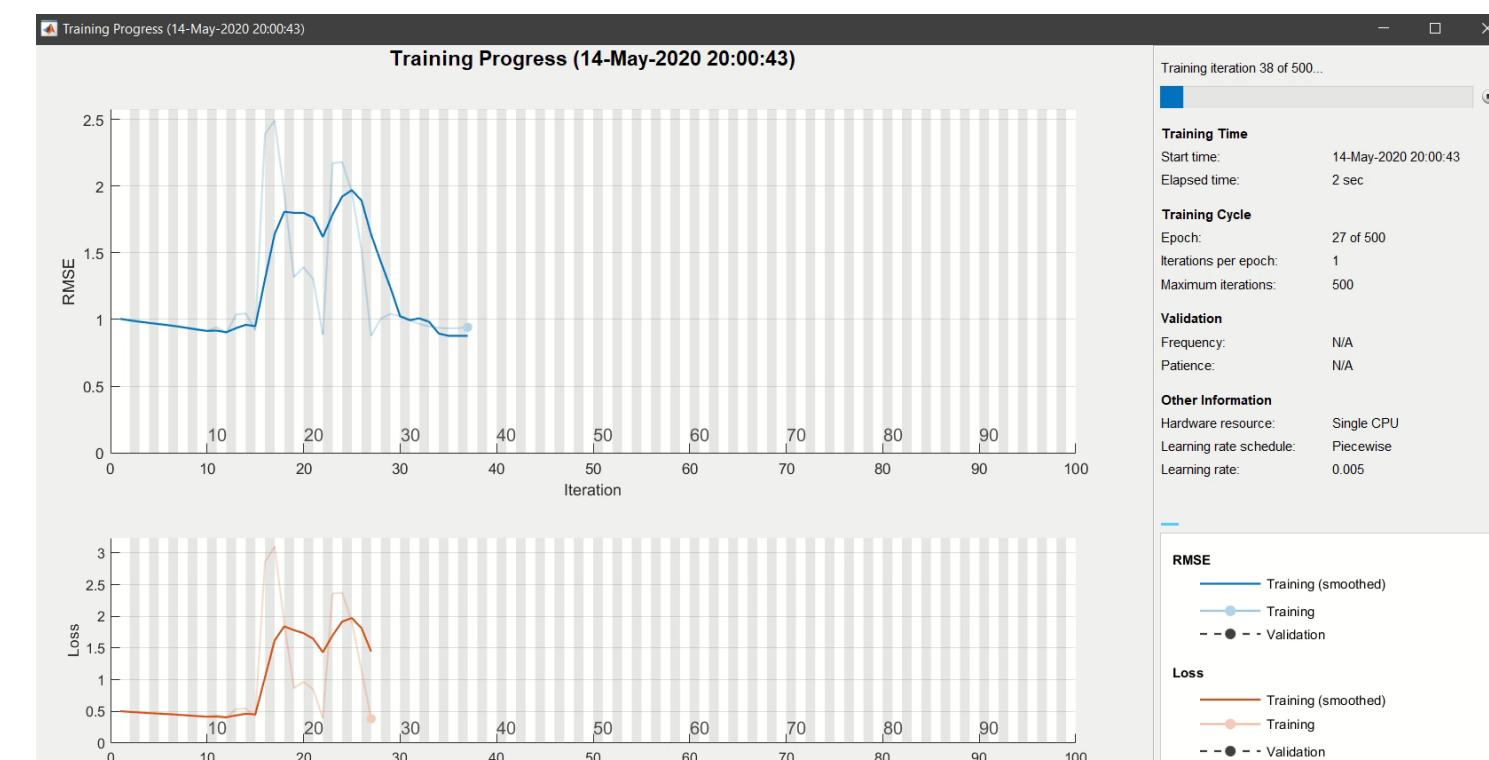
```

24  %% CREATE LONG SHORT-TERM MEMORY NETWORK FOR EFFECTIVE REPRODUCTION NUMBER
25  numFeatures = 1;
26  numResponses = 1;
27  numHiddenUnits = 50;
28  layers = [ ...
29      sequenceInputLayer(numFeatures)
30      lstmLayer(numHiddenUnits)
31      fullyConnectedLayer(numResponses)
32      regressionLayer];
33  options = trainingOptions('adam', ...
34      'MaxEpochs',500, ...
35      'GradientThreshold',1, ...
36      'InitialLearnRate',0.005, ...
37      'LearnRateSchedule','piecewise', ...
38      'LearnRateDropPeriod',100, ...
39      'LearnRateDropFactor',0.2, ...
40      'Verbose',0);

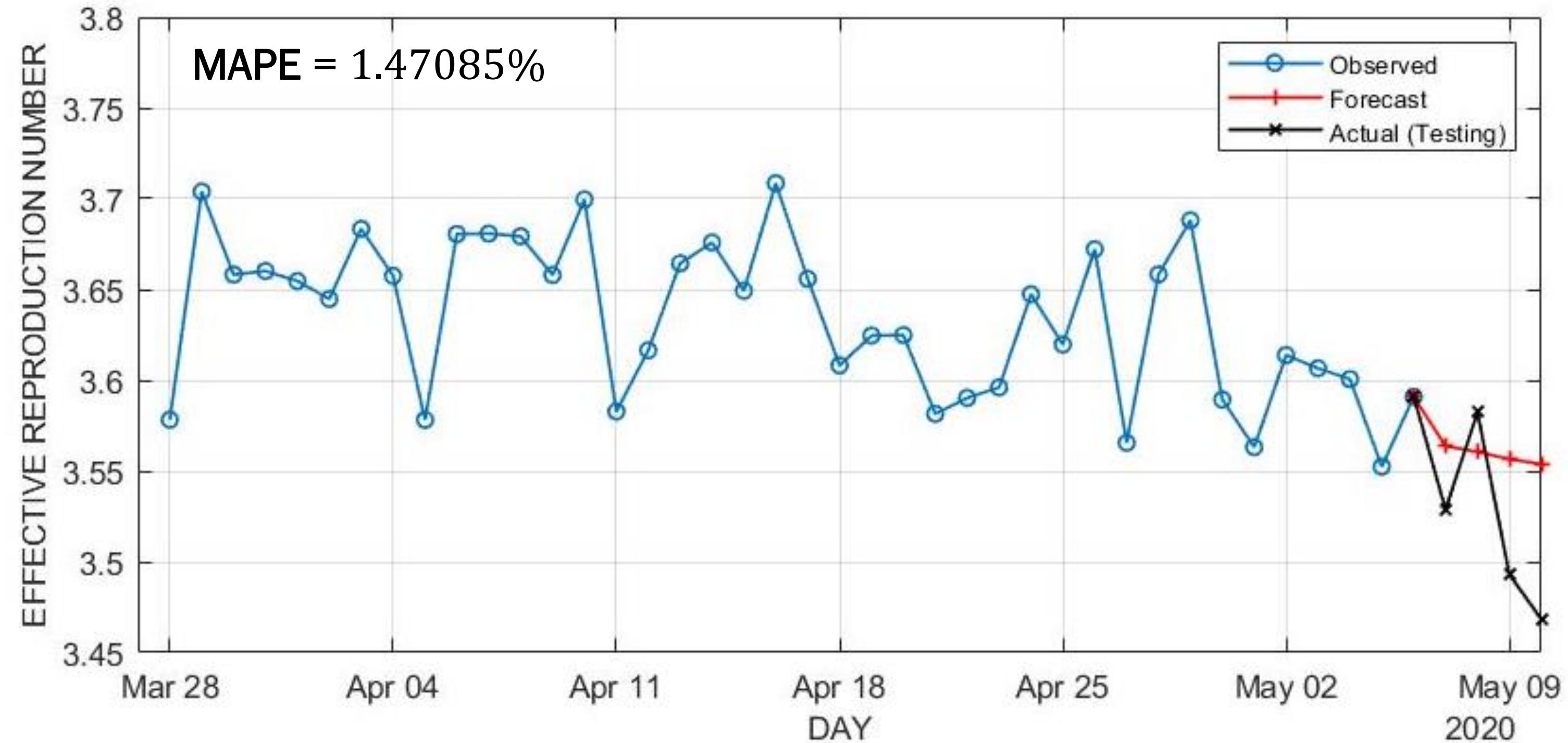
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Variasi → Bi-LSTM, MLP, CNN

- ‘sgdm’ : Stochastic Gradient Descent with momentum (SGDM) optimizer.
- ‘rmsprop’ : Use the RMSProp optimizer.



FORECASTING THE VALUE OF \mathcal{R}_t (Early Findings)



PREDIKSI KEDEPAN: Effective Reproduction Number, \mathcal{R}_t , Jawa Timur masih berada di sekitar angka 3.55. Artinya, satu orang yang terinfeksi berpotensi bisa menularkan penyakit COVID-19 ke 3-4 orang lainnya. **Hasil ini masih berupa dugaan, perlu penelitian lanjut.**



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MATUR NUWUN

Mathematics is The Science Which Uses Easy Words for Hard Ideas
- Edward Kasner -