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Parameters Estimation of Generalized Richards Model for COVID-19 Cases in Indonesia Using Genetic Algorithm

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Abstract

In this research, genetic algorithm was implemented to estimate parameters in generalized Richards model by adjusting COVID-19 case data in Indonesia. Data collected were the daily new cases and cumulative number of COVID-19 case in Indonesia from early March to early June 2020, that was reported by databoks.katadata.co.id. The best pair of parameters was selected based on the lowest cost function value, determined from the distance between data with estimated model and real data. Next, model with estimated parameters is used to predict new cases and cumulative cases for upcoming days. Numerical simulations were carried out so that the peaks and ends of the COVID-19 pandemic can be seen easily.

Keywords: *Parameters Estimation; Generalized Richards Model,; COVID-19; Genetic Algorithm*

1. Introduction

Novel coronavirus (COVID-19) was first identified in Wuhan, China, in the end of year 2019. That virus had been researched and identified as a genus betacoronavirus, the same as other acute and severe diseases Respiratory Syndrome (SARS) and the Middle East Respiratory Syndrome (MERS) [1]. This virus has become epidemic in China and also spread to other countries very quickly. It has brought big impact in all sectors of human life. Therefore, many scientists study COVID-19 in various perspectives and goals. In mathematics, many forecasting is done to find out when the covid-19 pandemic will end.

One mathematical model about the spread of disease that is widely studied by mathematicians to predict cases in epidemiology is [2–4]

$$\frac{dC(t)}{dt} = rC(t)^p \left(1 - \left(\frac{C(t)}{K}\right)^a\right), \tag{1}$$

where $C(t)$ is the cumulative number of cases at time t, r is the growth rate in the initial stages, and K is the final epidemic measure. $p \in [0, 1]$ is a parameter that allows the model to describe different growth profiles including constant events ($p = 0$), sub-exponential growth ($0 < p < 1$), and exponential growth ($p = 1$). Model (1) is the generalization from Richards model [5]

$$\frac{dC(t)}{dt} = \frac{r}{a} C(t) \left(1 - \left(\frac{C(t)}{K}\right)^a\right), \tag{2}$$

so the model (1) is called by generalized Richards model.

Nuraini et. al [6], predicted the number of COVID-19 cases in Indonesia using the Richards model and obtained the results that the peak of the epidemic in Indonesia would be occured at the end of March 2020 and would be ended in the middle of April 2020. However, the that prediction did not match the real data that happened in reality for until the end of May 2020 the number of new cases per day was still relatively increasing. Indeed, there is no model that really fit the real data. In addition, many factors influence the differences between estimated model and real data in the COVID-19 case in Indonesia, such as the lack of community efforts to carry out physical distancing or adhere to health protocols recommended by WHO.

In this study, estimations were performed to all four parameters r, p, K, and a in model (1) using genetic algorithm. According to Carwoto [7], genetic algorithm is a search algorithm based on Darwin's natural selection mechanism and genetic principles, for high-quality individuals found in a domain (population). The search is carried out with an iterative procedure to regulate the population of individuals who are candidates for the solution. This genetic algorithm has been reviewed by many researchers to estimate parameters (curve fitting) [8–10]. In this study, continuous genetic algorithms are used because the variables used are in the form of decimal numbers. The difference with the binary genetic algorithm is that in a continuous genetic algorithm, there is no need to decode.

2. Methods

First of all, researchers collected data of COVID-19 case in Indonesia from March, 2 until June, 8 of 2020. Then, the parameters in generalized Richards model was estimated using the Genetic Algorithm with Matlab 2018 software. In Genetic Algorithm, some features are needed, namely generations number (number of iterations), populations number (number of paired parameters), crossover point, mutation rate, and weighting constant. In this study, the generations number was 100 and populations number is 200. The crossover point for each parameter's mating was random from 1 until variable (parameter) number minus 1, the weighting constant for each generation was random real number between 0 and 1, and mutation rate of 0.1 was selected.

Estimate of twenty experiments was carried out. From all of the experiments, the parameters with the lowest cost are selected, which have the smallest difference with real data. The next step is simulating the model using the best estimated parameters numerically to predict the new cases and cumulative cases for upcoming days.

3. Results and Discussion

3.1. Parameters Estimation

The address databoks.katadata.co.id [11] presents data on the number of new cases and the cumulative number of COVID-19 cases in Indonesia as in Table 1 and simulated in Figure 1,Figure 2.

Table 1. Data of COVID-19 cases in Indonesia

Date	New Case	Cumulative Case
2020-03-02	2	2
2020-03-03	0	2
2020-03-04	0	2
2020-03-05	0	2
2020-03-06	2	4
2020-03-07	0	4
2020-03-08	2	6
2020-03-09	13	19
2020-03-10	8	27
2020-03-11	7	34
2020-03-12	0	34
2020-03-13	35	69
2020-03-14	27	96
2020-03-15	21	117
2020-03-16	17	134
2020-03-17	38	172
2020-03-18	55	227
2020-03-19	82	309
2020-03-20	60	369
2020-03-21	81	450
2020-03-22	64	514
2020-03-23	65	579
2020-03-24	107	686
2020-03-25	105	790

Based on the results in Table 2, the parameters pair with the lowest cost are $r = 1.067549$, $p = 0.670103$, $K = 65151$, and $a = 0.930868$. Numerical simulations in Figure 3 and Figure 4 with the values of those parameters give the

Date	New Case	Cumulative Case
2020-03-26	103	893
2020-03-27	153	1046
2020-03-28	109	1155
2020-03-29	130	1285
2020-03-30	129	1414
2020-03-31	114	1528
2020-04-01	149	1677
2020-04-02	113	1790
2020-04-03	196	1986
2020-04-04	106	2092
2020-04-05	181	2273
2020-04-06	218	2491
2020-04-07	247	2738
2020-04-08	218	2956
2020-04-09	337	3293
2020-04-10	219	3512
2020-04-11	330	3842
2020-04-12	399	4241
2020-04-13	316	4557
2020-04-14	282	4839
2020-04-15	297	5136
2020-04-16	380	5516
2020-04-17	407	5923
2020-04-18	325	6248
2020-04-19	327	6575
2020-04-20	185	6760
2020-04-21	375	7135
2020-04-22	283	7418
2020-04-23	357	7775
2020-04-24	436	8211
2020-04-25	396	8607
2020-04-26	275	8882
2020-04-27	214	9096
2020-04-28	415	9511
2020-04-29	260	9771
2020-04-30	347	10118
2020-05-01	433	10551
2020-05-02	292	10843
2020-05-03	349	11192
2020-05-04	395	11587
2020-05-05	484	12071
2020-05-06	367	12438
2020-05-07	338	12776
2020-05-08	336	13112
2020-05-09	533	13645
2020-05-10	387	14032
2020-05-11	233	14265
2020-05-12	484	14749
2020-05-13	689	15438
2020-05-14	568	16006
2020-05-15	490	16496
2020-05-16	529	17025
2020-05-17	489	17514
2020-05-18	496	18010
2020-05-19	486	18496
2020-05-20	693	19189
2020-05-21	973	20162
2020-05-22	634	20796

Date	New Case	Cumulative Case
2020-05-23	949	21745
2020-05-24	526	22271
2020-05-25	479	22750
2020-05-26	415	23165
2020-05-27	686	23851
2020-05-28	687	24538
2020-05-29	678	25216
2020-05-30	557	25773
2020-05-31	700	26473
2020-06-01	467	26940
2020-06-02	609	27549
2020-06-03	684	28233
2020-06-04	585	28818
2020-06-05	703	29521
2020-06-06	993	30514
2020-06-07	672	31186
2020-06-08	847	32033

prediction that the addition of new cases of COVID-19 in Indonesia reached the peak in early June 2020 of around 600 cases. In addition, it was also found that the COVID-19 pandemic in Indonesia is predicted to be ended in the middle of February 2021 with the maximum cumulative amount of 65067. This result is very much different from the results in the forecasting described earlier [6]. These results appear to be more in line with real data. However, the results obtained in this study are not very consistent with the real data considering the number of new cases added had reached 993 on June, 6 2020.

Table 2. The results of parameters estimation using genetics algorithm

Experiment	r	p	K	a	cost
1	0.716706	0.743492	62707.587272	0.579636	52.870182
2	0.736008	0.742655	69814.858676	0.519414	48.878518
3	0.594692	0.808475	61413.507735	0.315397	59.411524
4	0.830725	0.703028	70854.035223	0.887212	56.510482
5	1.067549	0.670103	65151.394033	0.930868	45.079011
6	1.240251	0.650344	76703.231660	0.851824	48.201949
7	0.759724	0.732778	55119.635198	0.659499	60.431946
8	1.339886	0.640612	70923.495648	0.892240	60.789361
9	0.609063	0.773894	45792.859491	0.601184	77.641809
10	0.709855	0.749629	62158.455983	0.531452	54.458610
11	0.754731	0.742767	72629.942305	0.478006	48.034166
12	0.756733	0.732361	63397.824797	0.622663	51.284776
13	0.559986	0.803320	45142.740320	0.453807	85.953706
14	0.896984	0.695427	64643.666655	0.877027	46.146775
15	0.685327	0.765630	63295.738195	0.434663	56.353092
16	0.610825	0.780651	52446.851536	0.486624	67.333387
17	0.898740	0.693779	69689.676954	0.870242	45.925880
18	1.039024	0.683308	54353.199361	0.797504	74.212424
19	0.915574	0.718942	51373.671962	0.546007	101.067937
20	1.164601	0.659994	70517.011444	0.860662	49.241770

4. Conclusion

Based on the results and discussion previously described, it was concluded that generalized Richards model with the best parameters fit with the real data of COVID-19 cases in Indonesia was

$$\frac{dC(t)}{dt} = 1.067549C(t)^{0.670103}\left(1 - \left(\frac{C(t)}{65151}\right)^{0.930868}\right).$$

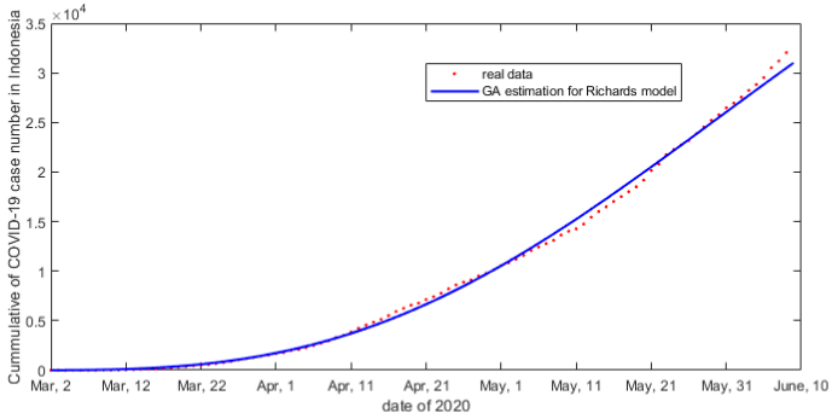

Figure 1. COVID-19 Cumulative Number in Indonesia

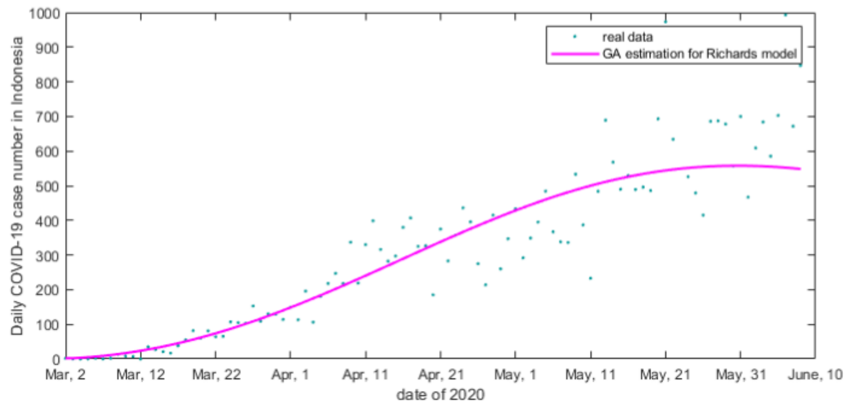

Figure 2. Daily COVID-19 New Case in Indonesia

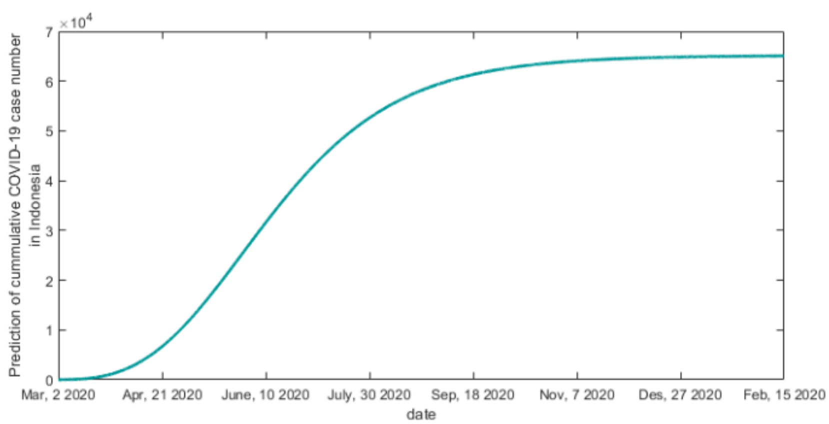

Figure 3. Prediction of COVID-19 Cumulative Number in Indonesia

Numerical simulations showed that the daily new cases would be reached the peak in early June 2020 of around 600 cases and would be ended in the middle of February 2021 with the maximum cumulative amount of 65067.

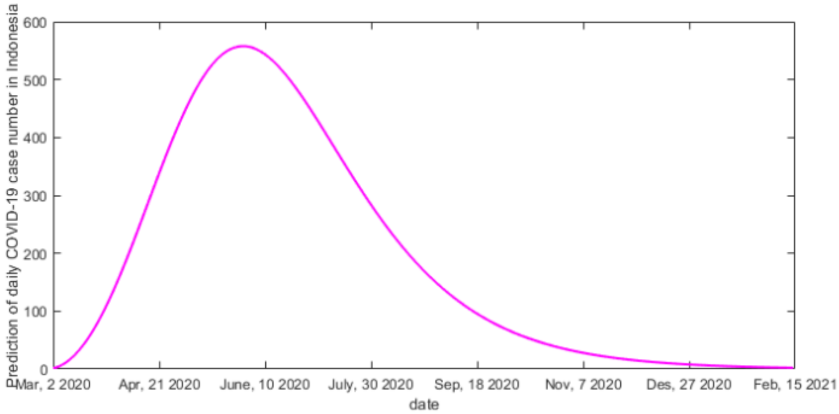

Figure 4. Prediction of Daily COVID-19 New Case in Indonesia

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