Analysis on Tidal Prediction Modeling by using Genetic Algorithm and It's Application in the West Sea of Korea

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Supreme Leader **Kim Jong Un** said as follows.

"We should boost the amount of electricity generated from wind and tidal power and from biomass and solar energy, and consistently expand the scope of the use of renewable energy."

Abstract

The antecedent tidal forecast used the solar calendar to analyze and forecast the tidal denervation data, so the analysis and forecast were to be done on an annual basis. And the antecedent tidal forecast used the traditional Least Square Method, which was rather inconvenient. This essay is going to ascertain the relationship between the Lunar Calendar and the tidal, and suggest the tidal predicting formula, the way of interpreting GA, and possibility of their application tested in the West Sea of Korea.

1. Research Modeling

The tide is the result of the tide-generating force which is the vector composition of universal gravitation and centrifugal force, given to the Earth by the Moon and the Sun. This force depends on the relative positions of the Earth, moon and the sun, which are all reflected in the shape of the Moon. And the lunar calendar uses this Moon, so the tidal process can be characterized according to this lunar calendar. For this reason, we first investigated the tidal process characters according to the lunar calendar.

Fig.1 shows the tidal water height on lunar January 1 and 15th from 1960 to 2009 (for 20 years) at Position 'ㅍ' in the West Sea of Korea.

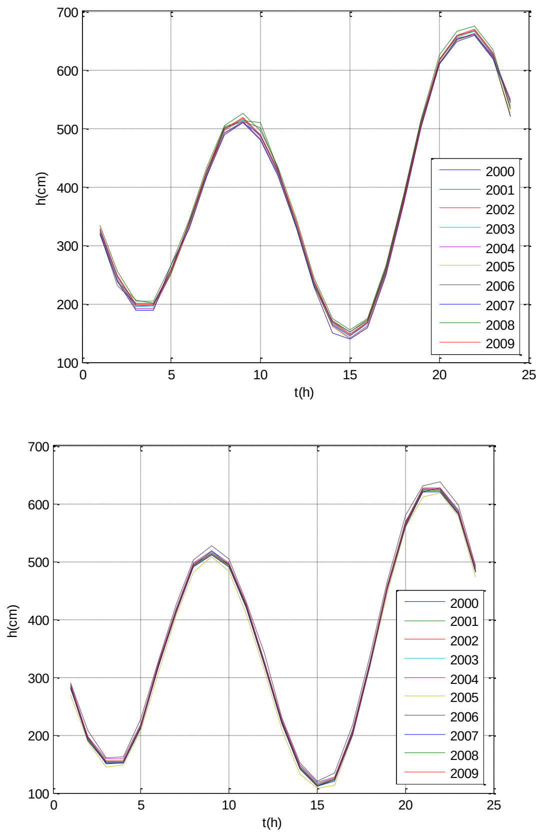

Fig.1. Tidal water height curve on lunar January 1 (left) and 15^{th} (right) during 1960-2009 in Position 'ㅍ' of the West Sea of Korea.

According to the analysis of observation data, there is no correspondence in the tide curves on solar January 1, nor is there such relationship between tide water level and solar day as that between tide water level and lunar day.

Considering this point, the dissonance regression model of tide water level procedure which is related to lunar date is evaluated as follows.

Fig.2 shows the tide level process curve to be modeled in connection with the parameter; in this tide process survey curve, the tide water levels were observed and recorded at T(time) on D(data) in M(month), on a continuous basis. Here, the tide water level values were achieved at an hour's interval every day during the standard year. The time range was from 0 o'clock to 24 o'clock, where the 24 o'clock means just 0 o'clock the next day.

When the tide water level curve is separately noted with the 2 segments - segment 412 and segment 420 - then the regression expression is as follows.[1]

$$\begin{cases} H_{m,d}(t_k) = \left\{x_{m,d}^{p_1} + R_{m,d}^{p_1} \times \left[\left(4\pi + \Delta A_{m,d}^{p_1}\right) - a_{m,d}^{p_1} \times s_{m,d}^{p_1} \times t_k\right] + v_{m,d}^{p_1}\right\}, & 0 < t_k < p_{m,d} \\ H_{m,d}(t_k) = \left\{x_{m,d}^{p_2} + R_{m,d}^{p_2} \times \left[\left(4\pi + \Delta A_{m,d}^{p_2}\right) - a_{m,d}^{p_2} \times s_{m,d}^{p_2} \times t_k\right] + v_{m,d}^{p_2}\right\}, & p_{m,d} < t_k < 24 \end{cases}$$

Here $H_{m,d}(t_k)$ represents tide water level; t_k ,time(distance 1); m , lunar month number; d , lunar date number(1~30); $X_{m,d}^{p_2}$, average value in p_2 period(M in Fig.1); $R_{m,d}^{p_2}$, amplitude coefficient in p_2 period(N in Fig.1); $\Delta A_{m,d}^{p_1}$ and $a_{m,d}^{p_1}$, phase control coefficient and angle control coefficient in p_1 period (G in Fig.1); $\Delta A_{m,d}^{p_2}$ and $a_{m,d}^{p_2}$, phase control coefficient and angle control coefficient in p_2 period (K in Fig.1); $S_{m,d}^{p_2}$, water level curve extension coefficient (J in Fig.1); and $V_{m,d}^{p_2}$, the micro water level control coefficient that is moving up or down the approximate curve (P in Fig.1).

Segment 1 (F in the figure, a curve from E to H) is approximate curve of $p_1(0 < t_k < p_{m,d})$ period). Segment 2 (I in the figure, the curve from H to L) is the approximate curve, which is divided into two on the $p_{m,d}$

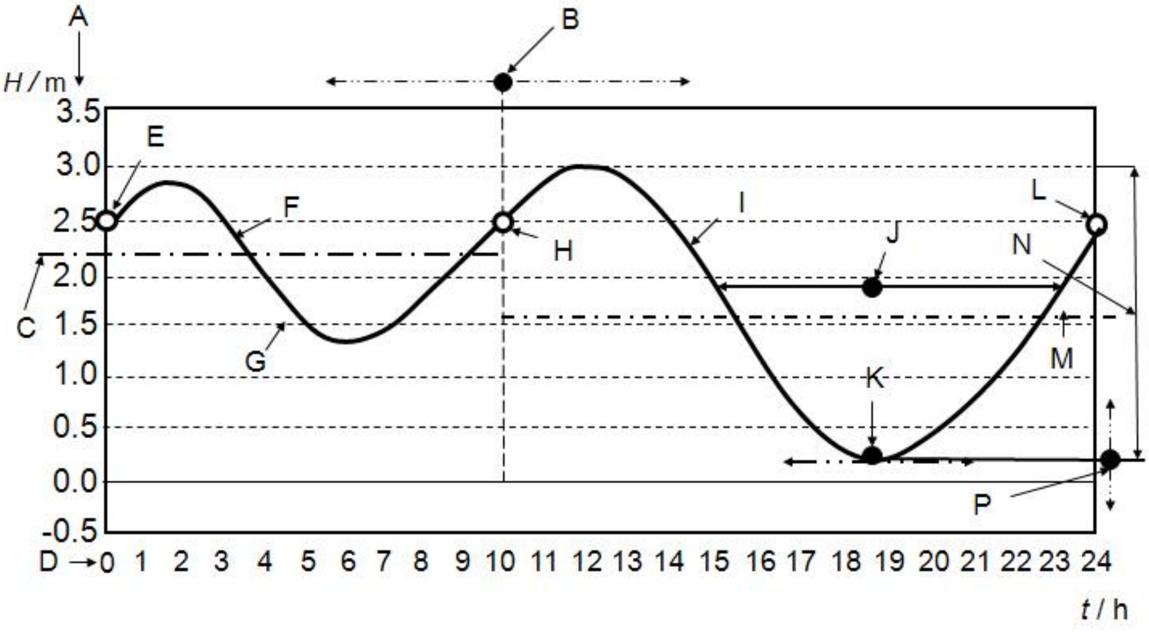

Fig.2. Tide height curve and model parameter

For p_1 period, the same parameter as mentioned above can be used. Once water height curved line separator $p_{m,d}$ is determined, average tide water height during p1 period (C in the figure) will be accounted as $X_{m,d}^{p_1} = \frac{1}{N_{p_1}} \sum_{t_k=0}^{Np_1} h_{m,d}^{p_1}(t_k)$.

In the formula above, we can calculate data number of N_{p_1} - $0 \sim p_{m,d}$,

N_{p_2} - $p_{m,d} \sim 24$ data number, $h^{p_1}_{m,d}(t_k)$ -tide height observed during the period p_1 at m (month), d (day) and t_k (hour), $h^{p_2}_{m,d}(t_k)$ - tide height observed during the period p_2 at m (month), d (day) and t_k (hour), and p_1 period's single controlling index $a^{p_1}_{m,d}$ out $a^{p_1}_{m,d} = \dfrac{4\pi}{N_H \times 60}$. Here, N_H is the number of hours (standard of 24 hours) during the Lunar Days. Time space is constant, so $a^{p_1}_{m,d}$ is the same as $a^{p_2}_{m,d}$.

2. Model calculation and It's accuracy evaluation

1) Model calculation by GA

In the research, $H_{m,d}(t_k)$ which refers to row m and column d is accounted as the genetic pattern of forecast model and the parameter value interval of the form's genetic regression model is determined as follows.

$$p_{m,d} : 8 \sim 17\text{(h)};\quad R^{p_1}_{md} : 0 \sim 10;\quad \Delta A^{p_1}_{md} : -2.5 \sim 7.5;\quad S^{p_1}_{md} : -0.2 \sim 0.2;\quad V^{p_1}_{md} : -5.0 \sim 5.0$$

The parameter's value interval of p_2 period is the same as the ones of the p_1 period. In the research, individual parameter's value such as p_{md} , $R^{p_1}_{md}$, $\Delta A^{p_1}_{md}$, $S^{p_1}_{md}$, $V^{p_1}_{md}$, $R^{p_2}_{md}$, $\Delta A^{p_2}_{md}$, $S^{P_2}_{md}$, $V^{p_2}_{md}$ which is needed in each tide prediction model is determined according to the regression analysis with GA model[2].

Tide height function which is calculated out by monetization is used as $H_{m,d}(t_k)$. If so, function value $H_{m,d}(t_k)$ has a certain deviation from the observed tide height and the deviations can be as following

$$d_1 = h_{md}(t_1) - H_{md}(t_1)$$
$$d_2 = h_{md}(t_2) - H_{md}(t_2)$$
$$\cdots$$

$$d_n = h_{md}(t_n) - H_{md}(t_n)$$

According to the Least Square Method, deviation F_{md} must satisfy the following formula:

$$F_{md} = \sum_{k=1}^{N_t} d_k^2 = \sum_{k=1}^{N_t} \left[h_{md}(t_k) - H_{md}(t_k) \right]^2 \Rightarrow \min$$

To satisfy this condition, the model parameters can be determined. This finally means that target function of GA is none other than the above formula.[2~3]

2) Evaluation of calculation accuracy/calculation accuracy evaluation

In order to evaluate the calculation accuracy of this model, we cheeked the one-month tidal progress data - the fifth month of the lunar calendar in 2012 - that were used in making model on Position "ㅍ" in contrast with the observation records.

The result shows that the observation time series nearly correspond with calculating curve, and the average duality accuracy was 90% and was improved 5~10% on average by/according to the harmony analysis law.

Conclusion

As seen above, the method of deciding the regression model of tide curve using dates of the lunar calendar and parameter as GA is regarded as a model that can overcome the weakness of the harmony analysis law in the past because the tidal table drawn up by this model is only used by the dates of the lunar calendar. We don't need to calculate every year separately in a given spot, so it can be an everlasting table, called "An immortal Tidal Table".

References

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[3] Robert H. et. al. Time Series Analysis and Its Applications, 412~500, Springer, 2006.

Keywords : tidal prediction, genetic algorithm, the West Sea of Korea.