Materials of Conferences

MODELING OF OPTICAL TELESCOPE DEVELOPMENT BY ENVELOPE CURVE

Trifonov K.V., Batova T.N.

St. Petersburg State University of Information Technologies, Mechanics and Optics, St. Petersburg, e-mail: Kirilltrif90@gmail.com, battat888@gmail.com.

Among the others methods of technical predictive modeling and scientific forecasting envelope curve method deserves special attention [1, 2]. The main advantage of this method is taking into consideration both evolutionary development and revolutionary development of optical telescope characteristics on account of combining local evolutionary development trends into one overall trend.

Applying of envelope curve is grapho-analytical method and its main idea is to get overall trend curve (macrovariable) by smoothing of the particular curves (microvariable) of evolutionary development and extend this trend to the future. Plotting of envelope curve is based on the following non-strict assumption: Macrovariable changes are rather slowly, smoothly, continuously and without any spikes compared to microvariables. The main aim of the method is the detection of the most probable date of switch in technologies evaluation. It also means that new products with advanced characteristics (by using results of fundamental and applied researches) will be developed as well.

Envelope curve can be plotted by smoothing of polyline that is composed of tangent lines to the particular curves [3]. In a particular case envelope curve can be defined as curve that has tangent line to the one of assembly of particular curves at each point of its space. However specific definition of envelope curve is impossible as well as this curve can't be plotted unambiguously.

Accuracy of such scientific forecasting depends on main parameter choice. This parameter should comprehensively characterize development of whole technical system at once. Hence first of all quantitative parameter *P* should be chosen.

Technical systems' development is either evolutionary or revolutionary. It means that development goes by increasing some quantitative parameter as far as face limit. After system's parameters get close to this limit, revolution switch in technologies, which gives birth to new quantitative parameter race within the new technology, occurs. It should be noted that limits could be difficult to evaluate and sometimes requires deep fundamental researches. There are many possible reasons to get into limitation: physical, technical, economical, law.

When new technology occurs, switching to it always isn't instant. Previous technology goes on its development dramatically fading away in light of inertia of interest. Genrikh S. Altshuller noted that inertia of interests consists of financial, science (pseudoscience), career and simple human (anxiety of losing accustomed system) interests. Thus economical factor adapts to such inertia of interests and system stays efficient through exploitation of nature resources [4]. Thereby two development curves can exist in one time: the one that is increasing and second one that is fading away. Also it should be noted that usually characteristics of new technology is lower than characteristics of previous technology at the beginning. However this compensates later due to higher level of parameter limitation.

In this paper the authors try to predict the development of optical systems on the example of optical telescopes to 2050. It should be noted that in this work we use only linear sections of optical telescope development curves. It is made because of lack of precise information about optical telescope characteristics especially for the initial stages of development. Information about highlighted stages is shown in Table.

Optical telescope development stages

Stage	Dates, years	Type of telescope	Variable quantitative parameter
I	1609–1686	Refracting telescope	Diameter, focus distance
II	1668–1800	Reflecting telescope	Diameter
III	1747–1897	Refracting telescope with different kinds of optical glass	Diameter
IV	1880–1948/1975	Reflecting telescope with glass mirrors	Diameter
V	1979–2018	Reflecting telescope with adaptive optics	Diameter of each element (adjustable optics), quantity of elements, speed and precision of calculations

Thereby it could be considered that there are five revolution switches in optical telescopes development history. Each of this stages accompanied by technology switch (from refracting telescope to reflecting telescope and back again when new technologies were developed). Diameter increasing was the main tool within every stage before it got into limitation. During the first stage people didn't know about the possibility of different optical glass combination. This fact resulted in optical telescopes with length about tens of meters, complexity of installation and alignment led to the limitation of diameter increasing. During second stage length was reduced by using mirrors in optical system. The largest mirror of this stage had a diameter of 126 cm; further increasing of the parameter was technically difficult. Besides this fact at this time already began to emerge optical telescopes with combination of optical glasses with different refracting index. The more detailed history of optical telescopes development is described in [5].

As mentioned above the main difficulty of this method is in choosing of parameter that will be used in forecast. In case of optical telescope on the one hand parameter "optical resolving power" could be used. This parameter ranges from 6^m (human eye) to 30^m (modern optical telescopes).

However object should be observed clearly and without distortion. Thus parameter "angular resolving power" could be used. This parameter ranges from 1' (human eye) to 0,1 (modern optical telescopes).

Hence we can conclude that it is not enough just to observe object (optical resolving power) it is also necessary to resolve fine details of object (angular resolving power). Thus and so we propose using the integral parameter P that takes into consideration both optical resolving power and angular resolving power. This parameter can be calculated on the basis of expert estimations and its starting point matches with the first stage beginning. At this point the parameter P is assumed equal to 5,5. At stage I parameter P varies within 5,5–8, at stage II in the range 6,5–11, at stage III within 8–14, at stage IV within 12–22 and at stage V within 17–29.

In this case as envelope curve we assume most smooth curve of possible that related to all or most of the individual optical telescopes development curves, some located at short range and some overlap. Analytically this dependence can be expressed in the following equation:

$$P(t) = 10^{-6} \cdot 2^{0,016(t-485)} + 7,5.$$

Initial equation was obtained by build-in MathCAD approximation function; its accuracy was increased by iterations of its coefficients. Resulting dependence has exponential shape. Other shapes may be possible for other technical systems: quadratic, logistic, linear, logarithmic. It depends on specificity of technical system and can be chosen directly in the course of forecasting.

Based on presented analysis, the following conclusions:

- It is advisable to use integral parameter for technical predictive modeling and scientific forecasting. Such integral parameter represents functional characteristics of whole system rather than specific technical parameters.
- Integral parameter has stable growth compared to individual technical parameters.
- Based on obtained forecast we are able to predict that by 2050 integral parameter reaches the value 42. That means that we can expect different combinations of optical resolving power and angular resolving power values. For example, one of possible combination sets optical resolving power parameter value equal to 34^m and angular resolving power parameter value equal to 0,005 seconds of angle.
- There is high probability that by 2050 revolution technology switch will have place.

Performed research shows that using envelope curve as method of technical predictive modeling and scientific forecasting is an excellent way of forecasting. It most completely takes into consideration both evolutionary development and revolutionary development of technical systems.

Such scientific forecasts can be the reason of early recognition of next-generation technologies as the result of reverse influence of technological forecast on technical system development.

References

1. Martino G. Tekhnologicheskoe prognozirovanie. – M.: Progress, 1977. – 592 p.

2. Ayers R.U. On Technological Forecasting. Report HJ-484-DF. Hudson Institute. – N. J. 1966.

3. Babich T.N., Kozeva I.A., Vertakova Y.V. Prognozirovanie i planirovanie v usloviyah rynka. M.: INFRA-M, 2012. – 336 p.

4. Altshuller G.S. O prognozirovanii razvitiya tekhnicheskih sistem // Oficial'nyj fond G.S. Al'tushullera. – URL:http://www.altshuller.ru/triz/zrts3.asp.

5. Sergeev A.N. Teleskopy: ot stekol k lazeram // Vokrug sveta. – 2009. – № 10. – URL: http://www.vokrugsveta.ru/vs/article/6782/5.

The work is submitted to the International Scientific Conference «New technologies, innovation, invention», Israel (Tel-Aviv) 29 april – 6 may, 2016, came to the editorial office on 25.04.2016.