© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 13.07.2022
Accepted for printing: 10.11.2022
Published: 22.12.2022

DOI: 10.15584/jetacomps.2022.3.11

PETER KOVÁČIK

The Alternative Model of Simplified Estimation of Measured Variables

ORCID: 0000-0002-0697-6499, doc. Ing., Ph.D., DTI University in Dubnica nad Váhom, Department of didactics and special subjects, Slovakia

Abstract

The article analyse errors which occur when airborne instruments are used and it creates basic idea about a chance of a man (pilot) to receive correct indication to his activity. The article introduces simplified model of numbers of measured values perception at short time and some possibilities of activity simplification which can lead to bigger lucidity and efficiency of measured values using. As a result is an alternative design of optimization of measured values estimation by a man who is influenced by stress situation, mostly by time.

Keywords: measurement, airborne instrument, probability, optimization

Introduction Educational merit of the article

The analysis in this article can improve communication between teacher and pilot student. In the beginning of pilot study, a student has not optimal idea about processing of lot of dates at short time and stress situation. A student has to understand what is important – he has to have sense (even though not exact) about complex situation at each moment. When he has enough time, he can solve different situations more precisely. The analysis shows complexity of decision making and its phases from very simplified version to more complex and more natural (fuzzy) view. Student can see, and understand at one place, conversion from simplified problem solving to more natural solving by estimation (but estimation needs experience). This analysis shows to student how estimation and experience are connected. As soon as possible student penetrates this fact, as better for his progress.

A cooperation of pilots or a pilot with pilot student is based on effective, strict and clear verbal communication. Any bigger size misunderstandings and inaccuracies can conduce not only to troubles from human point of view (influence of an overload which can tend up to the senselessness, jumps of the movement and impacts or injury resulting from it) and technical also (aeroplane particular parts damage as for possibility of air crash with all fatal effects). Pilots and air traffic control personnel are using human language, not exact number values, not only for communication but also at thinking and solving of different situations. This is a reason why lot of estimations and predictions of variables values, which do not have exact value but use some degree of precision, are at their thinking. These values are changing continuously at the time in addition.

The subject matter of the study. Causality of measurement errors of airborne instruments

An example: pilot is using deflections of elevator to control aeroplane flight at longitudinal plane and control of aeroplane altitude at specific situation. As input variables can be used values from aerometric altimeter and vertical speed meter. Both measuring instruments, in form of pressure sensors frequently at present time, measure barometric pressure at relevant place of aeroplane surroundings. Pressure sensing is influenced by errors which are originated by:

1. Changes of an air flow round pressure sensing place influenced by changes of velocity, temperature and pressure of air flow.
2. Changes of atmospheric moisture and water vapour condensation, eventually icing formation.
3. An angle of air flow stream is not constant round pressure sensor in dependence of aeroplane manoeuvring.
4. Location of pressure sensing places is not identical on different types of aeroplanes which induce variation even though the same sensors are used.
5. Pipes between place of pressure sensing and aerometric instruments influence a measurement when classic instruments concept is used.
6. When classic concept of aerometric instruments is used, there has to be specific pressure change to deform barometric boxes which induce position change of indicator pointers by transmission mechanism.
7. When electronic principle of instruments is used, indicated value is influenced by exactness of computing algorithm and tempo of computing system (time delay of computed value indication).

Inherent instruments involve errors and sense with specific accuracy. Measured values are influenced by errors resulting not only from principle of measurement and instruments construction, but additional occasions influence measurement on a board of an aeroplane moreover:

1. A temperature is changing depending up altitude of flight which causes changes of mechanical characteristics of particular instruments parts (expansion, elasticity, etc.).

2. Condensation of air humidity, caused by intense changes of temperature depending up flight altitude, produces surface moisture which influences function of instrument in light of short and long time moreover.

3. Different values of overload affect to all parts of instruments during flight. That mean, forces affect measured values, because forces influence during different time periods to not absolutely compensated parts of instruments at three dimensions.

4. It is similarly with influence of vibrations which are originated by turbulent atmosphere but also by all technical systems of an aeroplane. Frequencies of vibrations are important in respect of natural resonant frequencies of separate parts of instruments but instrument as a unit also.

5. Significant influence has electric and magnetic fields generated by all electric and electronic equipment including generation and distribution of electric energy on aeroplane board.

It is well known, man is bringing biggest errors to measurement outcomes by his inaccurate performance:

1. Man read out measured value inaccurately.
2. Man estimates value between number representations inaccurately.
3. Man do not observe an instrument from reasonable position.
4. Man estimates a position of instrument pointer when it is not stabilized, etc.

There are facts which make pilot activity difficult:

1. Pilot has usually short time to read up value shown by instrument.
2. Illumination of instruments is changing.
3. Sun blindness of pilot eyes is changing.
4. Vision of pilot is changing by overload influence:

– Visual angle width is on decrease

– A competence to discriminate colours is on decrease until total vision end in dependence of very small or lot of blood in pilot brain caused by overload.

5. There are changes of quality of seen information performance by pilot brain caused by influence of different stress factors:

– Coldness,
– Heat,
– Big amount of tasks,
– Threat of life:

▪ Crash,

▪ Impact during flight in: clouds, at night, above sea when pilot has not visual contact with ground,

– Down shoot, etc.

6. Degradation of brain oxygenation in dependence of smaller oxygen concentration when air pressure is smaller.

7. An implementation of completely digital indicators was not successful, because a pilot needs to have schematic idea about complex actual situation. Creation of this idea is strongly supported by an analogue presentation of situation by indicators, which is supplemented by precise numeric data, that a pilot can see when he has time enough.

Research methodologies and tools

By given analysis, a pilot can differentiate whole scale span of instrument into certain number of sectors, which pilot is using when he analyses actual situation and he do approximate calculations of particular flight parameters by his brain. Very approximately said, whole scale span of instrument is represented by rectangles and one of them represents an input variable into pilot reflection at actual situation.

Analysis of research results. The simplified model of measured values perception by a pilot

A centre of a specific rectangle is at position of instrument pointer and measured value is plus minus round this centre. Rectangle length is caused by negative influences to measurement mentioned above. That would means, rectangles are moving according to actual situation which would think and real activity of pilot considerably embarrass.

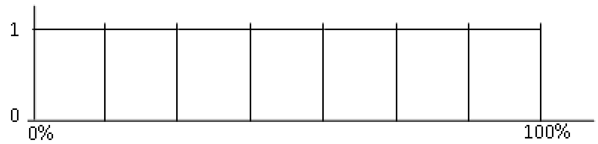

Figure 1. Division of a whole scale span of an instrument into certain number of sectors

A pilot needs sophisticated and well trained reactions to basic situations in advance, which can help to evaluate input data from instruments to him. That means, what are actual positions of instruments pointers (at least approximately) which indicate particular parameters of flight. This is a reason, why it is preferable when centres of relevant sectors of particular instruments (situated only in pilot brain) are stable and relevant value is situated insight of relevant rectangle. A probability of relevant value is lower in the direction out from the centre of sector that means probability of problem solving by corresponding value is lower. Probability, that measured variable is assuming value of adjacent sector, is increasing continuously which tends to idea that situation should be solved by another plan sophisticated in advance. Such arrangement of thinking about measurement is possible to express highly simplified by triangular shape with peaks of triangles at centres of sectors.

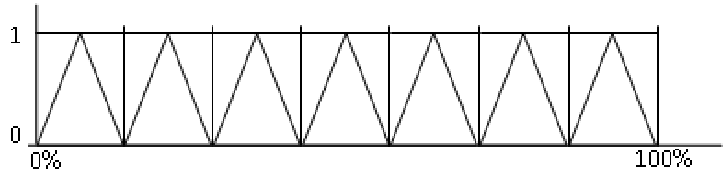

Figure 2. Substitution of rectangular shape sectors by triangle shape as expression of value truth

Decrease of probability measure of specific value is not linear and equal triangle. This fact results from analyse of negative effects to measurement which are additively and multiplicatively combined, and from which producer specifies instrument accuracy for predetermined conditions, for example ±1%. However, this condition is not possible to keep whenever which is a reason why tolerance of measurement can be bigger. Within the tolerance frame is needed to consider truth of variable at level 1. That means the peak of a triangle is not a point but certain sector, which is reason for trapezoid probability function of measured variable creation.

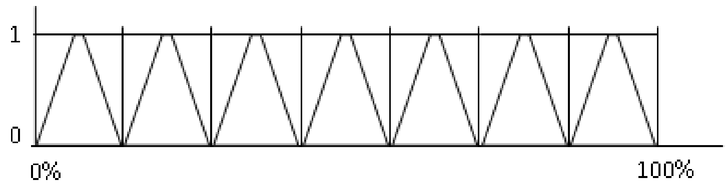

Figure 3. Decomposition of truth probability of instrument value

A number of considered instrument scale sectors affect problem solving expressively. If there are only two input variables and instrument scales are divided into five sectors there is 5 × 5 = 25 possible solutions. If there are more sectors 7 × 7 = 49; 9 × 9 = 81; 11 × 11 = 121, the number of solutions increases radically and there is a question: how many solutions pilot can have prepared in advance. Situation, when there are only two input variables is considerably simple. Decision making of pilot is influenced by more input variables usually. For example, if there are three input variables: 5 × 5 × 5 = 125; 7 × 7 × 7 = 343; 9 × 9 × 9 = 729; 11 × 11 × 11 = 1331. By given analysis, there exists an obligation to select appropriate number of sectors of measured variable and by this way reasonable sensitivity and preciseness of variable determination for standard solution:

1. 5 sectors mean one central and two towards higher and lower values. Such decomposition of instrument scale is relatively coarse and resulting solution will probably be fairly distant from optimal activity.

2. 11 sectors mean one central and five towards higher and lower values. It asks relatively large demands for estimations which are done at high speed activities and relatively big number of solutions for decision making at short time.

3. 9 sectors mean one central and four towards higher and lower values. Four sectors towards centre are possible to estimate really, but number of possible solutions is relatively large for decision making.

4. Adequate optimum is 7 sectors probably, which mean one central and three towards higher and lower values. This is possible to estimate really and resulting number of solutions is 49, which is approaching to abilities of trained pilot.

If 100% of measuring range is divided into 7 sectors, then one sector is 14% of measuring range. If top of trapezium is ±2% and it is subtracted from 14% of sector that results in ±5% for side part of trapezium from measuring range. Aforementioned alternative optimization of simplified sensing model could be accepted in the case, when trapeziums do not overlap. However it is convenient, when probability of one variable decrease then probability of neighbouring variable increase. That mean: 90% of particular value and 10% of neighbouring value, 50% of particular value and 50% of neighbouring value, etc. It results in side part of a trapezium is 10% of measuring range for probability change from 1 to 0.

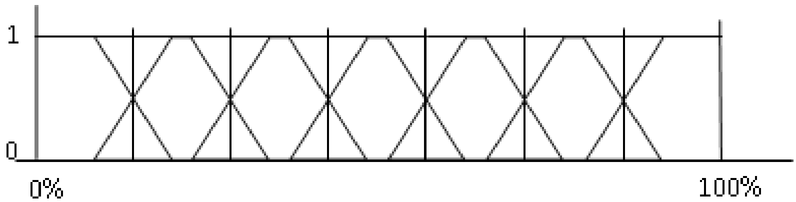

Figure 4. More real decomposition of truth probability of instrument value

A number and variety of negative effects to measurement preciseness indicate that mentioned shape of a trapezium is not kept from point of view of measurement errors distribution probability. From theory of measurement and probability used for measurement evaluation results, the most probable distribution of one sector is in the shape of the Gaussian curve.

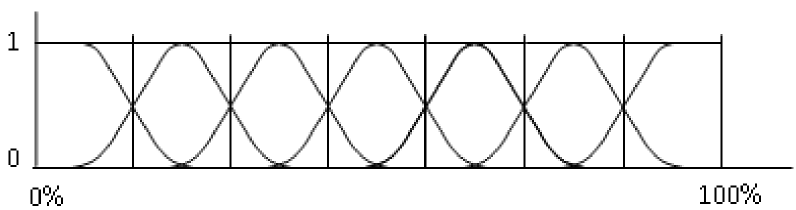

Figure 5. Decomposition of truth probability of indicated variable

However, the Gaussian curve shape is difficult for evaluation and technical realization in term of computation. This is a reason why it is preferable to substitute it by a trapezium again. But shape of a trapezium should be modified so, that difference of the trapezium to the Gaussian curve is minimal along whole curve.

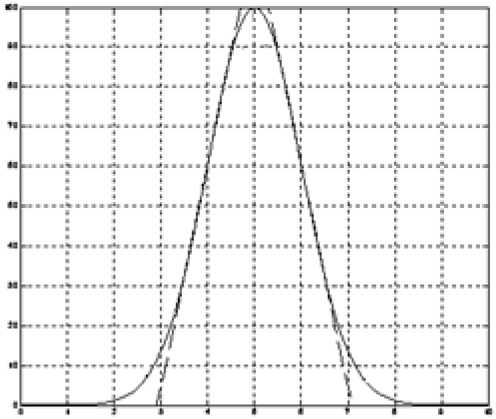

Figure 6. Substitution of the Gaussian curve by the trapezium

By this way there was created the trapezium with the shape optimized for problem solving with approximately identified measured values. Peripheral trapeziums of maximal and minimal values do not have descending parts towards extremes, their tops extends to extremes in consequence: a measurement of extremes is least precise and extreme values require extreme solution in wider measure.

Conclusion

The article describes suggestion of alternative model of measured value sensing by a man (pilot) when measured value is quickly seen (estimated) from instruments. This model can be used for high speed handling of measured values for approximate computation by a man, who is working with time lack and with high speed decision making. Simultaneously, the model is efficient base for exploitation at technical field to problem solving by fuzzy technology. Fuzzy technology uses similar principles as natural thinking of a man is, including estimation of values with specific probability of truth.

References

Driankov, D., Hellendoorn, H., Reinfrank, M. (1993). *An introduction to fuzzy control*. Berlin, Heidelberg: Springer-Verlag.

Kolesárová, A., Kováčová, M. (2004). *Fuzzy Množiny A Ich Aplikácie*. Bratislava: Stu.