Learning How to Transmit Morse Code with a Key and Digitization Model and Algorithms for Increasing the Speed of IT

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A B S T R A C T

This article proposes a mathematical model of Morse code recognition for evaluating the process of transmitting radiograms, modern methods for determining the transmission rate (speed) and objective evaluation of transmission with a key.

A R T I C L E I N F O

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It is obvious that the practice of maneuvering the duration of the transmission of tonal (single-frequency) sound signals underlies the coding and transmission of information by using Morse code. In other words, a unique way of encoding information by using a combination of short (dot) and long (dashes) (or dits and dahs) signals and spaces between them has been created and even today with the development of modern information and communication technologies it has not lost its relevance for radio communication due to its noise tolerance and its ability to transmit information even in extremely complex conditions. The proof of this can be seen in the fact that radiotelegraphy engineers are still members of the military communication units. [1]

In the system of training radiotelegraphy engineers, more attention is given to the study of Morse code and mastering of receiving information by listening. In practice, computer systems or Morse code sensors are often used in the process of Morse code transmission that is why there is not attention to transmission practice with a telegraph key in learning process. But according to authors' opinion this is a somewhat erroneous approach. [2]

There are different methods, different software applications, and simulators in different sources for listening and receiving Morse code. However, it is more difficult to find out such tools for learning how to transfer information with a key. There is not usage of automated monitoring of transmission process in existing software applications or hardware and automated monitoring of transmission in objective evaluation system.

Typically, the quality of Morse code transmission with a key is evaluated in the synchronous observation method by the instructors as given in Figure 1.

In this method various sound recording, recording and other devices can be used to ensure objectivity in the evaluation process. However, it is very difficult to achieve complete objectivity and the final rating always depends on the instructor's qualification, mood and attitude. The most effective way to ensure objectivity is to automate the process, transforming instructor's role from an "evaluator" to a "final decision maker", according to automated results. In order to recognize the transmitted radiogram in the automation tool (in the software application) to assess its correct transmission, it is necessary to determine the amount of one of the variable dimensions of Morse code or "reading" and compare it with the original (given for transmission) text. Typically, for such dimensions, the duration of dot sign transmission equals to τ_n.

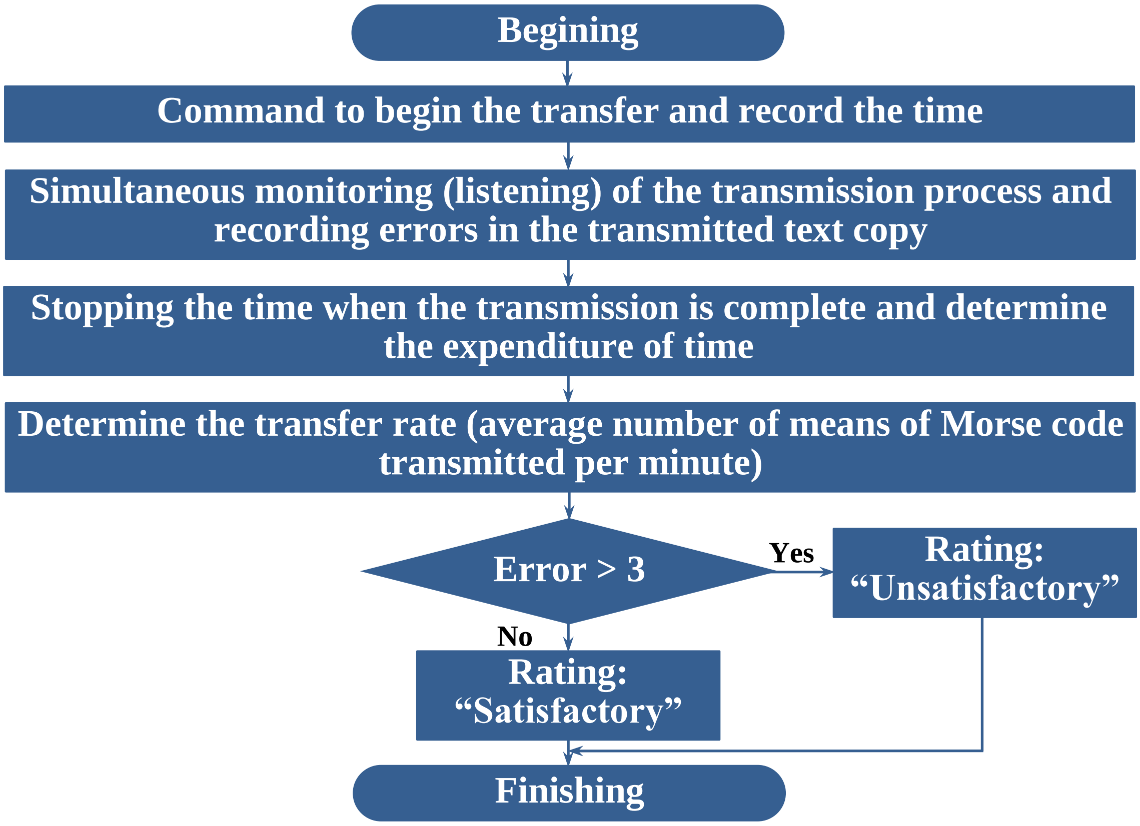

Figure 1 Instructor's action algorithm for transmission evaluation.

The process of automatic recognition of Morse codes with a key is technically a bit complicated. To solve this problem, we will take a closer look at the structure of Morse code. As a rule, if the "dot" ($\tau_{dot}=\tau_0$) sign of the letter in Morse code is transmitted continuously, the duration of "dash" sign equals $\tau_{dash}\approx 3\tau_0$, the space between them equals $p_t\approx\tau_0$, the space between two letter codes equal $p_{K}\approx 3\tau_0$ (Figure 2). In radiograms 5 letters are attached to a group (word), and the space between groups is calculated in the amount of $p_g\approx 7\tau_0$ [3,4]. According to the rules of radio communication, the size of radiogram does not exceed more than 30 groups. Transmission speed is measured with the number of groups transmitted per minute. Because of different duration of Morse code rules different radiograms may have different transmission speeds (especially in letter and digital radiograms).

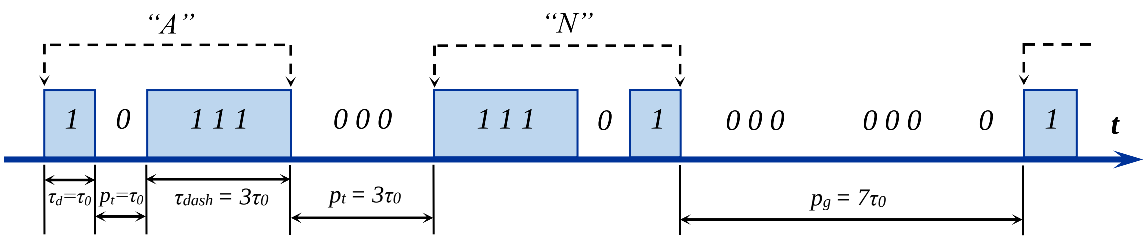

Figure 2 Structure of means of Morse code and space duration.

Based on these definitions, we determine mathematical relationships. Any M_R radiogram can be expressed as follows:

$M_R = m \cdot G_R$, (1)

Here G_R is a radiogram group (a word consisting of 5 letters or numbers), m is the number of groups in the radiogram.

Since the groups in the radiogram consist of five letters, $G_R = 5 \cdot K_M$, here K_M is the Morse code of the letters in the group. Morse code consists of a combination of one or more Morse means ("dots", "dashes") and it can be expressed as follows:

$K_M = K_1 K_2 \ldots K_i$ (2)

Here K_i is a sign of Morse code, which can be correctly defined as:

$$K(i) = \begin{cases} "dot", \tau \leq \tau 0 \\ "dash", \tau 0 < \tau \leq 3\tau 0 \end{cases} \quad (3)$$

Spaces are used to distinguish signs, letters and groups when transmitting Morse code. If $0<p<3\tau_0$ is space duration, the next sign will be the next sign of the letter being transmitted, if it is $3\tau_0 \leq p < 7\tau_0$, the next sign will be the first sign of the next letter, if it is $p \geq 7\tau_0$, the next sign will be defined as the first sign of the first letter in the next group.

Here the problem is that the base duration of the τ_0 ("dot") signal transmission depends on V_R transmission speed of the radiogram. Since V_R depends not only on the transmission speed of V_B sign, but also on the content of the radiogram (letter, number or mixed), it is not possible to determine the amount of τ_0 without beginning of transmission of the radiogram. For doing that, the transmission rate of the radiogram must be predetermined and transmitted at that speed (but this method is incorrect according to the teaching method) or it is needed to find the relationship between the transmission speed of V_R and τ_0 to determine the amount of τ_0 at the beginning of the transmission process and it must be applied the following signs to the recognition process.

It is obvious that, according to the rules of radio communication, the letter *"V"* is transferred three times in a row before transmitting each radiogram. So, if the code of the letter *"V"* is obvious as "• • • —", it will be possible to determine the amount of τ_0:

$$\tau_0 = \frac{T_{"V"}}{K_M + P} \quad (4)$$

Here $T_{"V"}$ is the time for transmit the code of the letter "V", P is the number of spaces between signs, and the amount of $T_{"V"}$ can be determined as follows:

$$T_{"V"} = \tau_t + p_t + \tau_t + p_t + \tau_t + p_t + \tau_{dash} = 3\tau_t + 3\tau_t + 3\tau_t = 9\tau_t \quad (5)$$

Here τ_t is the duration of transmission "dot", if it is as: $\tau_t = \tau_0$, $p_t = \tau_0$, $\tau_{dash} = 3\tau_0$, it will be as follows:

$$\tau_0 = T_{"V"}/9 \quad (6)$$

This means that this method has two objectives: first, the learner will be able to master the rules of radiogram transmission with a key, and for the automation tool there will be an opportunity to study the scene of the radiogram transmission before acting.

By using algorithm described above and the mathematical expressions, it will be possible to construct an algorithm for recognizing the transmitted Morse code (Figure 3).

In steps 2 and 3 of the algorithm transmission duration ($T_{"V"}$) of code "• • • —" in the word "VVV" and τ_0 are determined. In step 4, time for holding the key is measured. In steps 5 to 9 the amount of τ is compared with the criteria based on the amount of τ_0 and the transmitted signal is entered in the line of sign i of the letter K_{Mj} which is transmitted as "Dot" or "Dash". If the amount of τ is more than 3τ the transmitted code K_{Mj} = "$" is defined as an unknown letter and an error is recorded (steps 10 and 11). In step 12 the releasing time of the key p is calculated with the duration of the spaces. In steps 13 and 14 the amount of spaces is compared with the specified criteria and the transmitted code is concluded on the part of the letter K_{Mj} or the completion of transferring the letter. If the space duration is bigger than $7\tau_0$ or the number of letters (j) in the group reaches 5 (step 15), the transmitted letter is added to the new group (step 16). In steps 17, 18 the letter K_{Mj} of the radiogram text is fully formed and is compared with K_{Mj}^{Sample} in the sample text. If the letters do not match, in step 19 the letter is considered as an error and this error is recorded in step 20. If the transmitted letter matches, it is considered as transmitted correctly (step 21). In step 22 the amount of *l* of the transmitted groups is compared with the amount of *m* of the groups in the sample text. When the amount *l* is less than the amount of *m*, it returns to step 4 to transmit the nest letter code. Otherwise transferring the text is completed and transmission rate is calculated (step 23). In steps 24, 25 and 26 the quality of signal is evaluated according to the amount of errors made during the transmission, and in step 27 the transmission results are reflected.

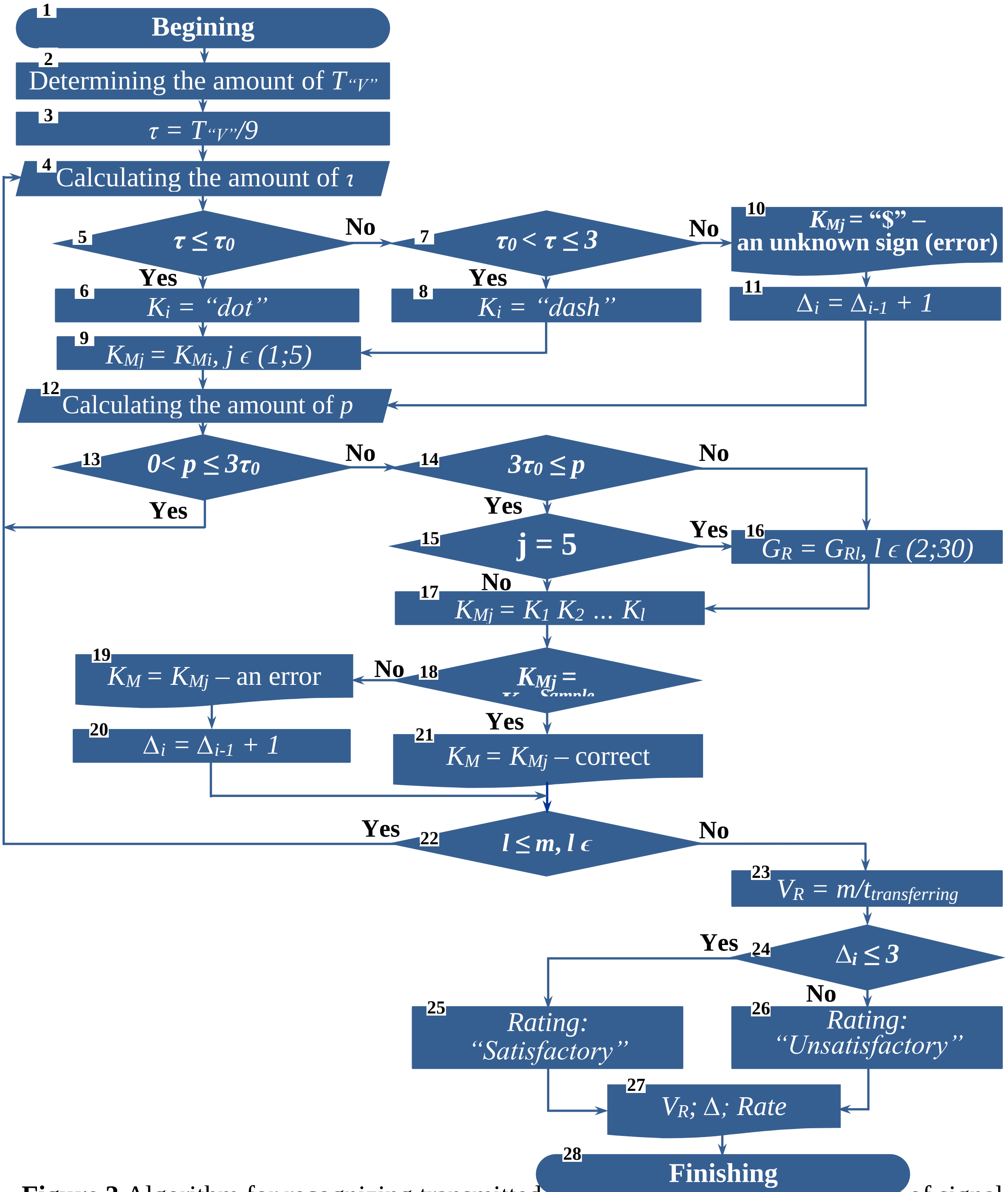

Figure 3 Algorithm for recognizing transmitted signal and evaluating the quality of signal.

Conclusions

In conclusion the most important issue in studying and speeding up the transfer of Morse code with a key is an objective assessment of the automated process of transferring the key. This requires the development of methods and algorithms for digitizing the process of recognizing the transmitted text, recording errors and determining the speed. That is why in this article the mathematical model of recognizing the transmitted Morse code has been created and a modern method of calculating transmission speed and assessing the quality of signal has been developed. By using the model and methods an algorithm for recognizing the transmitted Morse code and evaluating the quality of the transmission has been developed. The offered algorithm serves certainly to teach and speed up the transmission of Morse code through, the telegraph key in the complex simulator for radiotelegraphy engineers' training without instructor's involvement. In addition, this algorithm can also be used in systems that receive signals of Morse code automatically.

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