# The concept of construction an automatic system for ATC emotional condition monitoring

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Paper received 26.05.15; Accepted for publication 03.07.15.

**Abstract.** One of the most important problems currently connected with providing of persons automated control access to the resources of information systems by voice is permanent access control of air traffic controllers (ATC) to information resources of aviation ergonomics systems that is executed during operations. It is related because the safety of aircraft dependents of the reasonableness and correctness of ATC actions. The possible inadvertencies during their work can be connected with a constant feeling of neuro-emotional stress that is caused by increased responsibility for the decisions taking, lack of time and a large amount of controlled processes. This leads to increasing urgency of permanent monitoring of the emotional condition (EC) controllers. Special criterions of EC monitoring systems usage during controlling their access to information resources of ergonomics systems is small distances from the sound source to EC monitoring systems, small amount of controlled entities and necessity of control ensuring in the real time. Mentioned features of usage are determine requirements for the presentation of systems performance. Other important requirement is necessity of monitoring by ATC continuous speech. The aim of the current research was to develop a concept of construction of EC monitoring system for ATC, which is provide the execution of presented to system requirements and having high qualitative indexes. In accordance with developed concept the EC monitoring of ATC by means of continuous speech is reduced to keyword monitoring which are extracted from smooth continuous ATC speech and based on a comparative analysis of the control and reference informative parameters characterizing the isolated (primarily vowels) phonemes. The article briefly describes a method for increasing the performance of the search subsystem and key words extracting in continuous ATC speech.

***Keywords:*** *Air traffic controller, emotional condition, speech recognition, pitches frequency, formants, phoneme*

## Introduction

One of the most important problems currently connected with providing of persons automated control access to the resources of information systems by voice is permanent access control of air traffic controllers (ATC) to information resources of aviation ergonomics systems that is executed during operations.

Currently, on the ATC work a visual inspection is made by the Senior ATC. It is clearly insufficient.

For the reducing of the influence of human factors on the aviation safety the authors propose performing of permanent remote automatic EC monitoring of an ATC during its operation [4,5,7].

The EC monitoring is performed in the real time and allows preventing access to information resources for ATC which are in inappropriate EC.

As a biometric criteria of ATC for the monitoring realization proposed to utilize its voice.

The aim of the current research was to develop a concept of construction of EC monitoring system for ATC, which is provide the execution of presented to system requirements and having high qualitative indexes. The present disclosure contains the concept development results.

Special criterions of EC monitoring systems usage during controlling their access to information resources of ergonomics systems are small distances from the sound source to EC monitoring systems, small amount of controlled entities and necessity of control ensuring in the real time.

Mentioned features of usage are determine requirements for the presentation of systems performance. Other important requirement is necessity of monitoring by ATC continuous speech. Another important factor is necessity of monitoring of continuous ATC speech. Marked that the provision of this requirement is facilitated by such specific requirements for the ATC as the necessity to use a special phraseology ensuring moderation of speech and fixed distance between the sound source and the microphone.

In the current paper are presented the basic principles and algorithm for the realization of the automatic remote EC monitoring, and disclosed the work of basic subsystems EC monitoring system which is developed by means of ATC work specifics:

1. An ATC during the audio exchange with the aircraft crew members uses the professional phraseology set.
2. An ATC and the aircraft crew members leads the alternately information exchange.
3. The ATC speech has to be measured with clear and concise words pronouncing.

The specific feature that is peculiar to ATC is stress tolerance as a result of special psychological training. Moreover, ATC has to be completely healthy.

Problems to be solved by developed EC monitoring system:

1. The administrator assisting (means the Senior ATC), which is provide the visual management for ATC activities, to prevent access to information resources of persons, whose occupy an ATC workplace unauthorized and whose are in inappropriate EC, by the signal when detects a possible violation (which is especially important during standalone ATC work).
2. The EC changes tracking during ATC operation.
3. Obtaining of the documentary violation evidence during the accidents causes investigation, emergency and flight accidents.

## The basic principles and algorithm of the remote monitoring of the EC of ATC

1. Control is performed by means of smooth continuous speech that is based on analysis of speech signal parameters, fixing during the audio exchange between the ATC and aircraft crew members.
2. The EC monitoring on the continuous speech is reduced to its implementation by means of speech fragments extracted from ATC continuous speech. Under the speech

 

fragments means words and phrases that is often used by ATC during the operation, including a part of professional phraseology. (for the ATC professional phraseology is established by normative documents).

3. The EC monitoring is based on methods of pattern recognition theory [2] using the developed system of speech signal parameters.

The developed algorithm for EC monitoring that is based on abovementioned principles includes the following steps:

– scanning and discretization of the speech signal;
– pre-processing, which consists in noise reduction;
– the continuous speech segmentation on speech fragments (words or phrases);
– "key" speech fragments (words, phrases) searching in continuous speech and their allocation;
– EC determination of ATC on the dedicated speech fragments (during the monitoring process implement the speech signals parameterization and classification).

Phoneme segmentation is offered, as well as noise reduction, performed using wavelets [1,3,6]. Segmentation problem by means of wavelets solving thought interphoneme transitions detecting in which the signal undergoes significant changes at multiple scales studies and consequently characterized by an increase in the wavelet coefficients for many levels of detailing, while the stationary portions phonemes wavelet coefficients are grouped near certain scale. Searching of interphoneme borders is reduced to finding moments of wavelet coefficients increasing at a significant amount zoom levels. The significant is the selection of wavelet basis, which should allows describing fixed speech signal with the relatively small amount of non-zero coefficients. Appropriate for the problem solving as wavelet basis used Haar wavelets, Daubechies 5 or 6.

Below is briefly reviewed work of the main subsystems of the EC monitoring developed system (speech fragments allocation from the smooth continuous speech subsystem and EC monitoring subsystem by means of allocated speech fragments), constructed based on mentioned principles and algorithm.

**Construction of EC monitoring subsystem of ATC by the speech fragments extracted from the smooth continuous speech**

The EC monitoring is based on the phonemes analysis of speech fragments that is extracted from the smooth continuous ATC speech.

The main subsystem steps are: keyword segmentation into phonemes, recognizing phonemes, parameterization vowel phonemes, classification of speech signals and a decision about EC of controller.

During the work performing the observations have been conducting, the essence of which was to analyze the different parameters, that characterize the speech fragments of different duration. Speech fragments were spoken by professional artists simulated their presence in various emotional conditions. For the research was developed appropriate technique. The experiment involved 10 people (5 men and 5 women).

For the experiments results the basic informative parameters were chosen parameters that are characterized the vowel phoneme included in the keyword (pitch frequency parameters based on it (irregularity et al.), Formant frequencies) and the duration of utterance of the key word.

Research has confirmed the information available in the literature that the frequencies of the pitch are rather clear upward trend in the change of man EMC line "depression, stiffness - the norm - the excitement."

An analysis of literary sources and conducted research have shown, that the pitch frequency has a clear upward trend in the change of the human condition through the "depression, stiffness - the norm - excitement», but wherein the pitch frequency for the same phonemes in different speech fragments may differ significantly.

It was the ground to provide EC monitoring of ATC by permanent pitch frequency calculation for the specific speech fragments (extracted from smooth continuous speech) and checking the fact of pitch value belonging to the appropriate ATC condition of "norm" (calm condition). Not belonging of pitch value is evidence that the ATC is in inappropriate EC.

For the increasing of validity EC monitoring system work permanently analyzes the changes the values of formant frequencies (and their relationship) phonemes, constituents of speech fragments, isolated from the smooth continuous ATC speech. The most informative formant frequency are F2, F3, F4, and the relationship of these values of formant frequencies, obtaining at the moment of monitoring, to their values, calculating when finding speaker in the normal condition.

**Subsystem of searching and allocation of "key"speech fragments from the smooth and continuous ATC Speech**

For the "keyword" from the smooth continuous speech can be apply the speaker independent Artificial Neural Networks (ANN), that is trained to recognize the keywords. ANN usage allows significantly improve the accuracy of the EC monitoring system in comparison with existent systems, work of which based on determination of the distances between the control and reference (listed in the database) vector of parameters.

However, it is obvious that a simple words enumeration using ANN is counterproductive; it does not allow the monitoring system to operate in the real time.

The authors have developed a method of fragments searching in continuous speech, the usage of which can significantly speed up the search process.

The increasing of system work achieving by quick words discarding, deliberately not included in the database (dictionary) keywords before processing by subsystem of EC monitoring. In this case, the ANN usage is only necessary to hypotheses checking derived from the application of the developed method.

The speech fragments searching in the ATC smooth continuous speech by which EC monitoring providing is based on applying of the developed models of speech fragments and their comparison with models that contained in the models database.

The database content is filled according to the results of preliminary research on the recognition of phonemes (allophone) and phonemic analysis.

The basis of the subsystem selection speech fragments (words and phrases) from the smooth and continuous speech is its segmentation into phonemes and pause with

the further searching speech fragments which contain specified amount of vowel and consonant phonemes.

Let's demonstrate the principle of a subsystem work on the spectrogram word «Переключитесь» example (this word is a part of phraseology command «Переключитесь на высоту», which is often used by air traffic controllers), depicted in the figure 1.

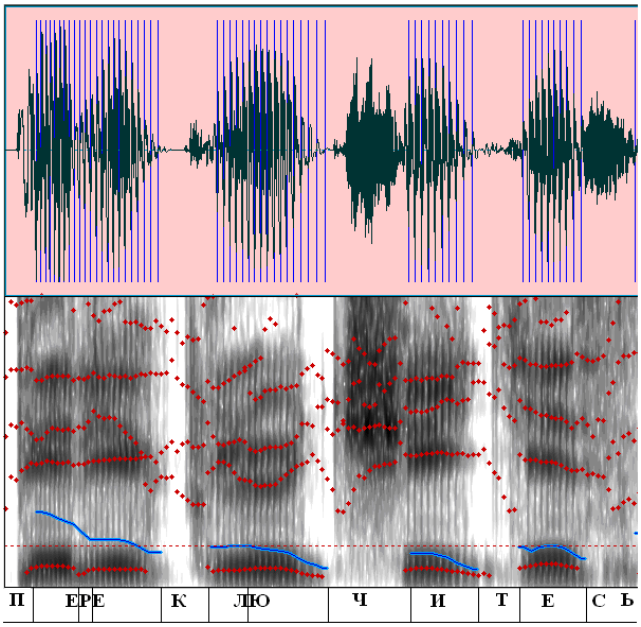


**Fig. 1.** the spectrogram of keyword «Переключитесь»

The figure 1 shows how the specified phraseological keyword can be represented as a sequence of phonemes and pauses.

Significant milestone when applying the developed method for increasing the speed of the system is the modeling of words extracted from the ATC continuous speech. These represent models are the sequence positions intended for the recognized phonemes; wherein under proper recognition understands the phonemes recognition (primarily vowels) and phoneme assignment to a particular class (e.g., class, voiceless consonants).

The words models database is created during registration dispatchers (ATC). When applying the developed method are discarded words, models that do not correspond to the words models, forms the basis of the words models. It is important is the lack of recognition of the need for all phonemes keyword - enough to recognize (or refer to a specific class) several phonemes - their sequence will be a hypothesis to confirm or cast by ANN.

In such a way the implementation of the developed method for increasing the speed of the system is perform the following sequence of actions:

1. Making the model control keyword, built by the first words of the recognized phonemes.
2. Search in the database of the models of words that match the word, entered for analysis. In case of model-based words in the corresponding model hypothesized that analyzed the word is in the dictionary.
3. Hypothesis checking using ANN.
4. In case of "positive" outcome of the hypothesis checking proceed to the EC monitoring of ATC.

Note that the developed method does not require additional time, because phoneme segmentation and recognition of phonemes are elements of the sequence of actions committed during the EC monitoring of ATC.

During the EC determining of ATC it is important thing of absence of necessity for recognition of phonemes of the speech fragment of password - for the EC determination enough to recognize only the first few vowel phonemes.

The efficiency of the allocation of the required voice fragments of a continuous speech depends on the quality of its segmentation into phonemes.

## Conclusion

1. Presented the basic principles the subsystems construction of the developed EC monitoring system for ATC to information resources in the real time, the operation of which is based on the analysis of the parameters characterizing the speech fragments extracted from continuous speech.
2. Developed a system of informative parameters for monitoring the EC of ATC.
3. Developed a way to improve the performance of the subsystem selection of "key" speech fragments of ATC continuous speech.
4. The applying of the EC monitoring system can significantly improve safety dramatically decreased in numbers the amount of accidents and emergencies due to the reduction of the human factor.

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