Almost all biological phenomena, physiological functions and psycho-physiological conditions can be more completely analyzed, in details, by contemporary technologies and methods. Foremost among these is digital signal processing (DSP). DSP is one of the most powerful technologies that will shape science and engineering in the twenty-first century. It refers to methods of filtering, processing and analyzing signals based on the assumption that signal amplitudes can be represented by a finite set of integers corresponding to the amplitude of the signal at a finite number of points in time (Mulgrew et al., 2002; Kuo and Gan, 2005). By definition, DSP is the study of signals in a digital representation and the processing methods of these signals. Also, DSP analyses audio and speech signal processing, video and digital image processing, signal processing, radar (and sonar) signal processing, spectral estimation, statistical signal processing, signal processing for communications, sensors and biomedical signal processing, seismic data processing, etc. (Blackledge and Turner, 2001). Basically, DSP is designated...
Speech analysis is the branch of speech science that estimates the parameters of the model for speech production from acoustic measurements of speech signal. One such very important feature is voice fundamental frequency (F0). The main parameter, fundamental frequency, originates from the biomechanical characteristics of human vocal tract and could be used as additional cognitive parameter for classification process. F0 tracking algorithms generally do not identify the temporal location of each vibration of the vocal chords but rather are based on average time spacing between numbers of vibrations. The averaging, typically due to the use of an autocorrelation type of calculation is used to improve the accuracy of tracking. F0 extraction plays an important role in speech processing and has a wide spread of applications. For this reason, many methods to extract the F0 of speech signals have been proposed. With these methods, the F0 of each short time speech frame is determined based on the periodicity or the harmonic structure of the frame, by detecting the time delay that maximizes the autocorrelation function of the frame, or by detecting the frequency whose multiples correspond to the harmonic frequency peaks in the frequency spectrum of the frame (Noll, 1967; Schroeder, 1968; Sondhi, 1968; Rabiner et al., 1976; Wise, 1976). Recently, several new F0 estimation methods have been proposed for providing better performance than traditional methods (Boersma, 1993; Kawahara et al., 1999; Liu and Lin, 2001; Shimamura and Kobayashi, 2001; De Cheveigne and Kawahara, 2002). F0, if reliably estimated, could be useful for a wide range of applications, and has been successfully employed to examine the influence of stress, effort, fatigue and physical and mental load (Ruiz et al., 1990; Brenner et al., 1994).

Sound signals. All living beings communicate among themselves in two different ways: by chemical language pheromone and other substances) or through production of sound signals. Both communication means contain information that are indispensable for survival. Speech is a fundamental means of human communication, while animal communication is based on vocalization (Fig. 1). Animal vocalizations range from almost periodic vocal-fold vibration to completely atonal turbulent noise which may provide insight into the degree to which detailed features of vocalizations are under close neural control, as opposed to more directly reflecting biomechanical properties of the vibrating vocal folds themselves (Tokuda et al., 2002). The acoustic characteristics of animal, as well as of human vocalizations, have been postulated to provide information about many important attributes of the vocalizer, including its size, age, sex, reproductive status and emotional state in a non-invasive way (Fitch, 1997; Jeon et al., 2009). Formant-like spectral features are present in vocalizations of many different nonhuman animals, including alligators, some birds, and many mammals including nonhuman primates (Fitch, 2000).

Fig. 2. Variations of fundamental frequency of pronounced material (test word divided into segments) in three different functional states – rest, regular working situation, and in the state of stress.
ADS v2.0. Employing the basic principles of digital signal processing approach, the algorithm based upon a simplified version of a general technique for F0 extraction, has been implemented and incorporated in the speech analysis application ADS v2.0, created by the authors. The application ADS v2.0 was written with primary purpose to increase efficiency of the procedure, especially in filter phase and/or computing of the basic voice parameters (Vučković, 1997). All component applications are interactive, and are to be performed in real time. It is developed according to specific consumer needs and referred to medical and psycho-physiological stress assessment (Čičević et al., 2009). It supports the standards in visualization of the digital signal using different functions for calculation of the standard parameters of speech (segment length, intensity, frequency, etc.) as well as supporting list of specialized function for concrete application in the projected area. The new idea is based on transforming one-dimensional sound quantity into 2-dimensional wave shapes and their classification by using standard pattern recognition procedures. The recognizing application is implemented, tested and proved the value of new approach.

Application. To increase system performances, data base with referent samples is stored in the operative memory. DSP module has responsibility to filter input signal. After that, normalization and pick elimination procedures are performed. Recognizing procedure compares normalized input signal with all samples from referent samples base, and one sample, which is most similar to input one, represents the final result of the process. The parameter data file that is generated could be printed immediately. Nevertheless, its format is not suitable for statistical analysis because it has too many details. The other reasons for further computing are the linkage to standard statistical applications. Those problems are solved with FILTER application. The user could select the parameters for filtering. Using that defaults, the application filters the original ASCII prm.txt into format that is suitable for statistical analysis (usage of SPSS software, for instance).

In conclusion. Proposed software application showed applicability for individuals’ stress and emotional tension estimation in real working situation. The results of the study on air traffic controllers indicated that F0 increased significantly after being exposed to stress in comparison to the resting state, as well as in subjects who worked under regular conditions. Such findings indicate that F0 shows significant sensitivity both to stress and working intervals of relatively long duration, when accumulation of workload takes place.