Comparative Measurements of Psychophysiological Parameters by Thermal and Video Cameras for Vibraimage Processing

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Abstract: *Study to determine psychophysiological and emotional parameters of testee by vibraimage technology using television cameras operating in visible and infrared spectral ranges was conducted. The comparative characteristics of the mathematical expectation, standard deviation and variability of psychophysiological parameters for the visible and thermal images of human head are obtained. Was concluded the impossibility to automatically transfer the norms obtained by vibraimage technology when determining the psychophysiological parameters of a person in visible light to measure the psychophysiological parameters of a person using thermal imaging cameras.*
Keywords: *vibraimage, thermal image, video stream, emotions, psychophysiology.*

Vibraimage technology (Minkin, 2017; 2020; Minkin&Nikolaenko, 2008) converts streaming video using software processing into two different image components that reflect the amplitude and frequency characteristics of objects vibrations and movements in the frame. Moreover, as the original video image stream, a streaming video image obtained in the visible light reflected from the object in the wavelength range (0.4–0.8) μm and the thermal image emitted by the object or infrared (IR) in the wavelength range can be used (8–14) μm. Currently, there are a large number of photodetectors and television cameras in both of these wavelength ranges (Serrano-Cuerda et al., 2014), and the technical parameters of such cameras satisfy the basic requirements of the vibration technology for video sources (image format of at least 640×480, frame rate 30 fps, dynamic range of at least 80 dB). To obtain information about the movement of an object, both images (thermal and visible) are similar in terms of information content, however, each of these images has its own advantages and disadvantages.

The main advantage of the visible light range (VLR) is the high contrast of the image (relative to IR), the simplicity of obtaining it using cheap television cameras, the ability to adjust the illumination of an object using lighting devices and the widespread use of television cameras in VLR.

The main advantages of thermal light or self-radiation in the infrared range (IRR) are its stability and independence from changes in the illumination of the IRR. Moreover, thermal imaging cameras are always more expensive than conventional ones and the thermal imaging image is different and less contrast than the image of the IRR, since its contrast is determined by the temperature difference, and not the reflectivity of a person's face.

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It is known that the vibration characteristics of an object can be determined in different ways (Minkin, 2017b) and, depending on the method used, the measured vibration characteristics of an object should differ only within methodological errors (Novitsky, 1975; Minkin, 2019). However, this does not guarantee automatic transfer of measurement algorithms from one method to another to obtain identical measurement results.

The purpose of this work is to compare the results of vibraimage processing of VLR and IRR to determine the possibility of transferring the regulatory framework of the emotional parameters of the VLR to the IRR.

Materials and Methods

To conduct a comparative study, a multiple (10 times) simultaneous measurement of the psychophysiological parameters of one testee by Microsoft LifeCam Studio television camera for VLR and COX CG40 television camera for IRR was performed. The format of both television cameras was set to the same 640×480 as well as a frame rate of 30 fps. The location of the subject's head along the horizontal frame line was at least 200 elements for each television camera. The time of each measurement was 600 seconds. The psychophysiological and emotional parameters of the subject were measured using the Vibraimage PRO10 program (Vibraimage PRO10, 2020). Statistical processing of the results was carried out by the VibraStat program (VibraStat, 2020).

Results

Figure 1 (a, b) shows the images of the test subject in the visible and infrared ranges during this study.

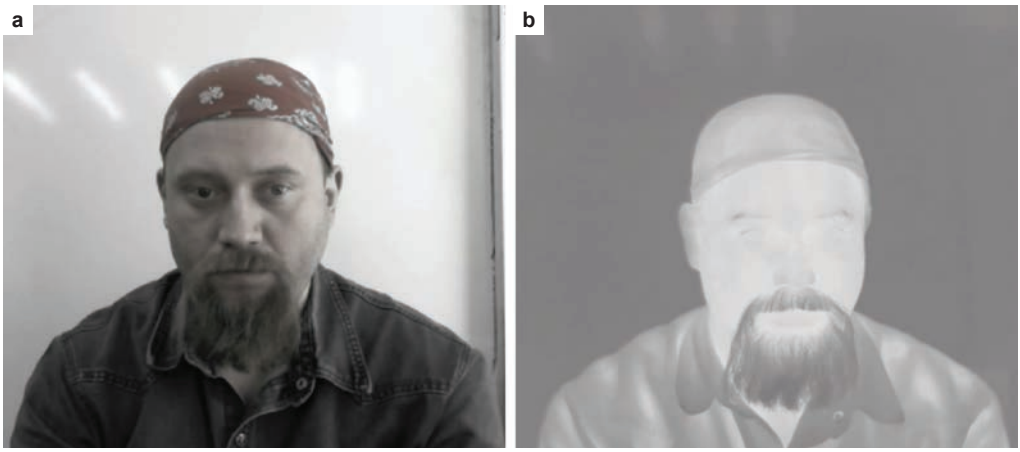

Fig. 1. The image of the test subject in the VLR **(a)** and IRR **(b)**

The averaged results of 10 measurements of 12 emotional parameters in the IRR are given in table 1.

Table 1

Average results of 10 measurements of 12 emotional parameters in the IRR

12 Emotional Parameter Results									
Parameter	Min	Avg	Max	Vi	Parameter	Min	Avg	Max	Vi
Aggression (20 ~ 50)	21,6	31,9202	45,8	13,2	Stress (20 ~ 40)	30,3	37,0694	43,3	7,8
Tension (15 ~ 40)	20,9	36,5226	50,3	19,5	Suspect (20 ~ 50)	29,4	35,0248	41,1	7,3
Balance (50 ~ 100)	61,3	73,8261	85,5	5,8	Charm (40 ~ 100)	28,9	66,3377	81,3	20,6
Energy (10 ~ 50)	10,3	16,4467	24,6	18,0	Self-Regulation (50 ~ 100)	49,0	68,6007	81,9	10,2
Inhibition (10 ~ 25)	65,7	84,6897	110,4	11,0	Neuroticism (10 ~ 50)	8,3	60,7125	102,7	33,2
Depression (20 ~ 50)	20,2	26,47	30,6	8,4	Happiness (50 ~ 100)	28,4	28,64	28,7	0,3

The average results of 10 measurements of 12 emotional parameters in the ICD are given in table 2.

Table 2

Average results of 10 measurements of 12 emotional parameters in ICD

12 Emotional Parameter Results									
Parameter	Min	Avg	Max	Vi	Parameter	Min	Avg	Max	Vi
Aggression (20 ~ 50)	13,4	20,6881	33,9	10,3	Stress (20 ~ 40)	25,5	33,9384	43,5	9,1
Tension (15 ~ 40)	20,3	37,4488	49,8	15,5	Suspect (20 ~ 50)	24,8	30,5246	35,3	7,1
Balance (50 ~ 100)	9,9	48,9929	82,4	31,3	Charm (40 ~ 100)	20,2	68,1656	83,5	25,4
Energy (10 ~ 50)	1,3	5,04391	12,2	48,2	Self-Regulation (50 ~ 100)	16,5	57,0573	81,8	25,1
Inhibition (10 ~ 25)	78,6	93,1271	126,9	11,4	Neuroticism (10 ~ 50)	7,2	55,4221	106,1	28,3
Depression (20 ~ 50)	20,0	42,22	49,5	17,3	Happiness (50 ~ 100)	26,0	26,99	28,9	2,1

The results of emotional parameters measurements obtained in different light spectrums given in tables 1 and 2 have noticeable differences, which we will analyze in more detail in the next chapter.

Discussion

Comparative histogram of the mathematical expectation of emotional parameters obtained by VLR (group 1) and by IRR (group 2), shown in figure 2.

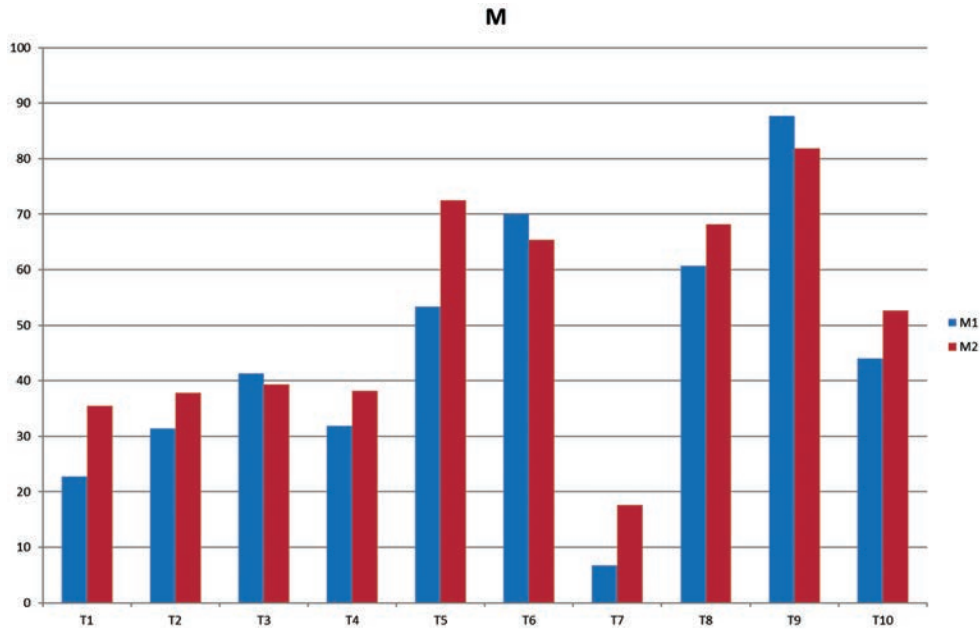

Fig. 2. Comparative histogram of the mathematical expectation of emotional parameters obtained by VLR (group 1) and IRR (group 2)

The maximum change in emotional parameters, measured in different spectral ranges, is observed for parameters T1, T5, T7, and the difference between these values is approximately 30% for parameters T1 and T5 and 60% for parameter T7. These differences are clearly not random in nature, but are related to the fundamental differences between the thermal image and the television image. The fact that both images carry information about the movement of an object absolutely does not guarantee the identity of this information, since the real vibration image differs from the ideal vibration image (Minkin, 2007).

Comparative histogram of the standard deviation of emotional parameters obtained by ICD (group 1) and by IRR (group 2), shown in figure 3.

The maximum change in the standard deviation of emotional parameters, measured in different spectral ranges, is observed for parameters T1, T5, T8, T10, and the difference between these values is about 30% for parameters T1, T8 and T10 and more than 60% for parameter T5. The difference in the standard deviation of the measured values confirms the different nature of the studied images and cannot be corrected by the systematic measurement error (Novitsky, 1975).

Comparative histogram of emotional parameters variability obtained by ICD (group 1) and by IRR (group 2), shown in figure 4.

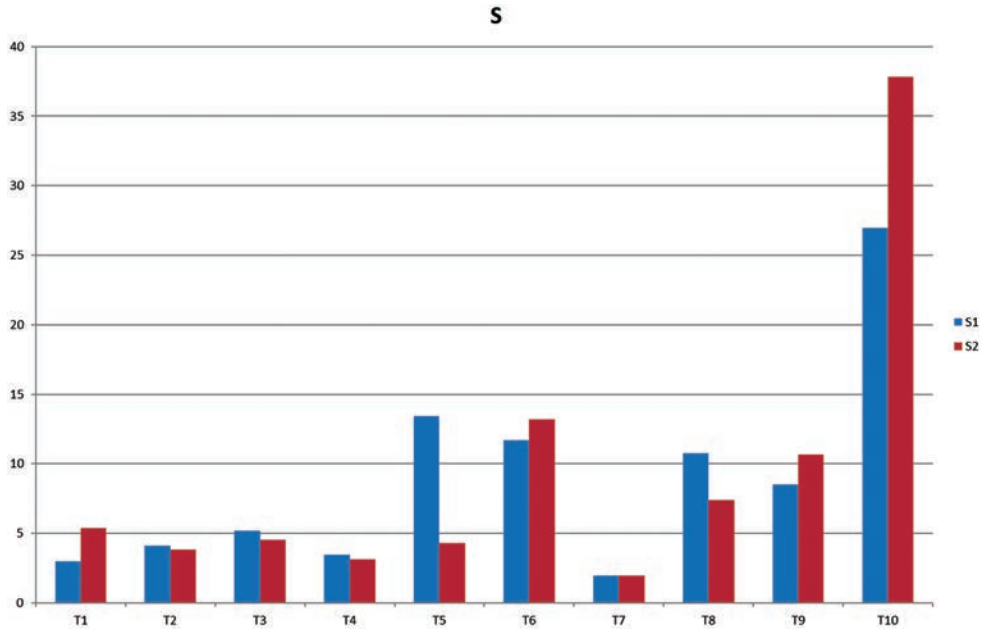

Fig. 3. Comparative histogram of the standard deviation of emotional parameters obtained by ICD (group 1) and IRR (group 2)

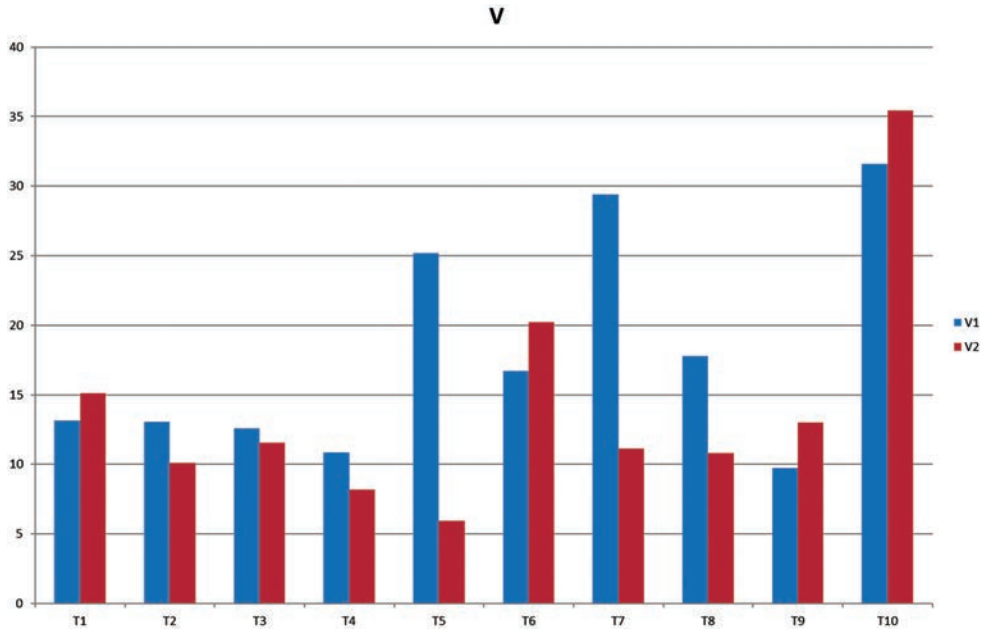

Fig. 4. Comparative histogram of emotional parameters variability obtained by VLR (group 1) and IRR (group 2)

The comparative histogram of the variability of emotional parameters also has significant differences in parameters T5, T7 and T8. It turns out that almost all emotional parameters have significant differences in the main characteristics obtained on the basis of VLR (group 1) and IRR (group 2) of images.

Conclusion

Comparison tests showed the impossibility of transferring the norms established by vibraimage processing in VLR for measuring emotional parameters in IRR. Consequently, to conduct research on emotional parameters in IRR, an independent set of statistical data and determination of their own norms for parameters are necessary, and correction of equations for calculating emotional parameters (Minkin, 2020) in IRR is possible.

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