Microvibration analysis using vibraimage technology and artificial intelligence for COVID-19 diagnosis

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Physiology of Activity

Movement is fulfillment of what exists potentially.

(Physics III, 335 BC) Aristotle

Every reaction of brain activity could be characterized as muscular movement. (Reflexes of the brain, 1863)

Ivan Sechenov

Reflex movements associated with emotions.
(The Expression of the Emotions in Man and Animals, 1872)

Charles Darwin

 A person does not have random movements.
(The Interpretation of Dreams, 1899)

Sigmund Freud

The main processes in physiology are excitation and inhibition.

(Nobel Prize speech, 1904)   Ivan Pavlov

An introvert and an extrovert differ in the direction of the energy distribution (Psychological types, 1921)

Carl Jung

Physiology of Activity

Human movements are discrete in time, as they are corrected by feedback. (Biomechanics research, 1935)

Nikolai Bernstein

Psychophysiological processes are associated with the exchange of energy and information within or between physiological systems of a person. (Cybernetics: Or Control and Communication in the Animal and the Machine, 1948)

Norbert Wiener

Amplitude and intensity of reflex movements characterized aggression. (On Aggression, 1966)   Konrad Lorenz
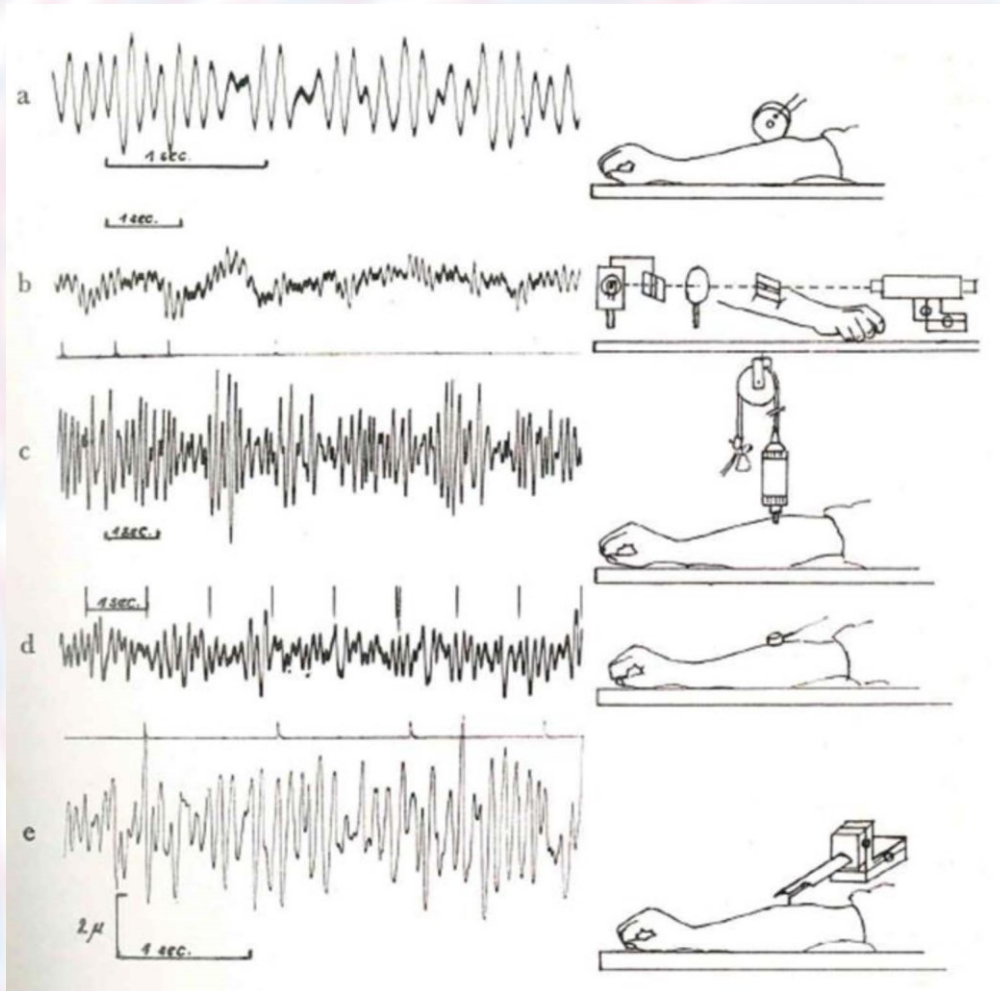
Every intention is linked by a muscle settings (Myokinetic psychodiagnostics, 1954)   Mira y López

All people have not one intelligence, but having a number of autonomous intelligences (Frames of Mind: The Theory of Multiple Intelligences, 1983)

Howard Gardner

Muscle Microvibration - the Source of Energy for Warm-blooded Animals, Hubert Rohracher


Constant microvibration of muscles provides energy for constant temperature of a human body and is the basis of thermoregulation in humans and warm-blooded animals.

Hubert Rohracher (1946)

Various mechanical methods and devices for studying microvibrations used by professor Rohracher.

Muscle Microvibration is Constant Process during Sleep and Wakefulness
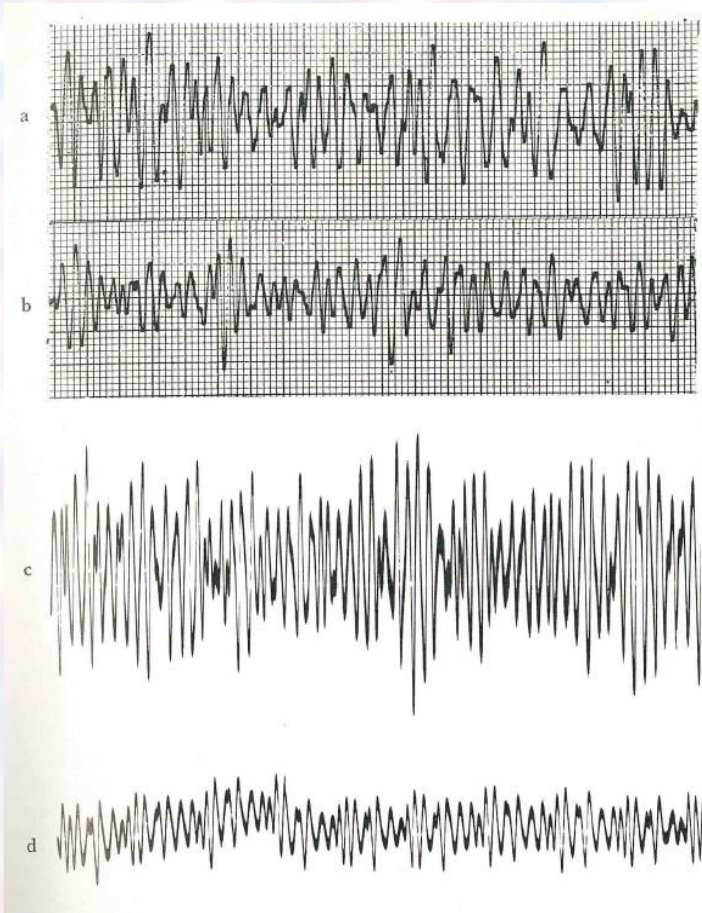
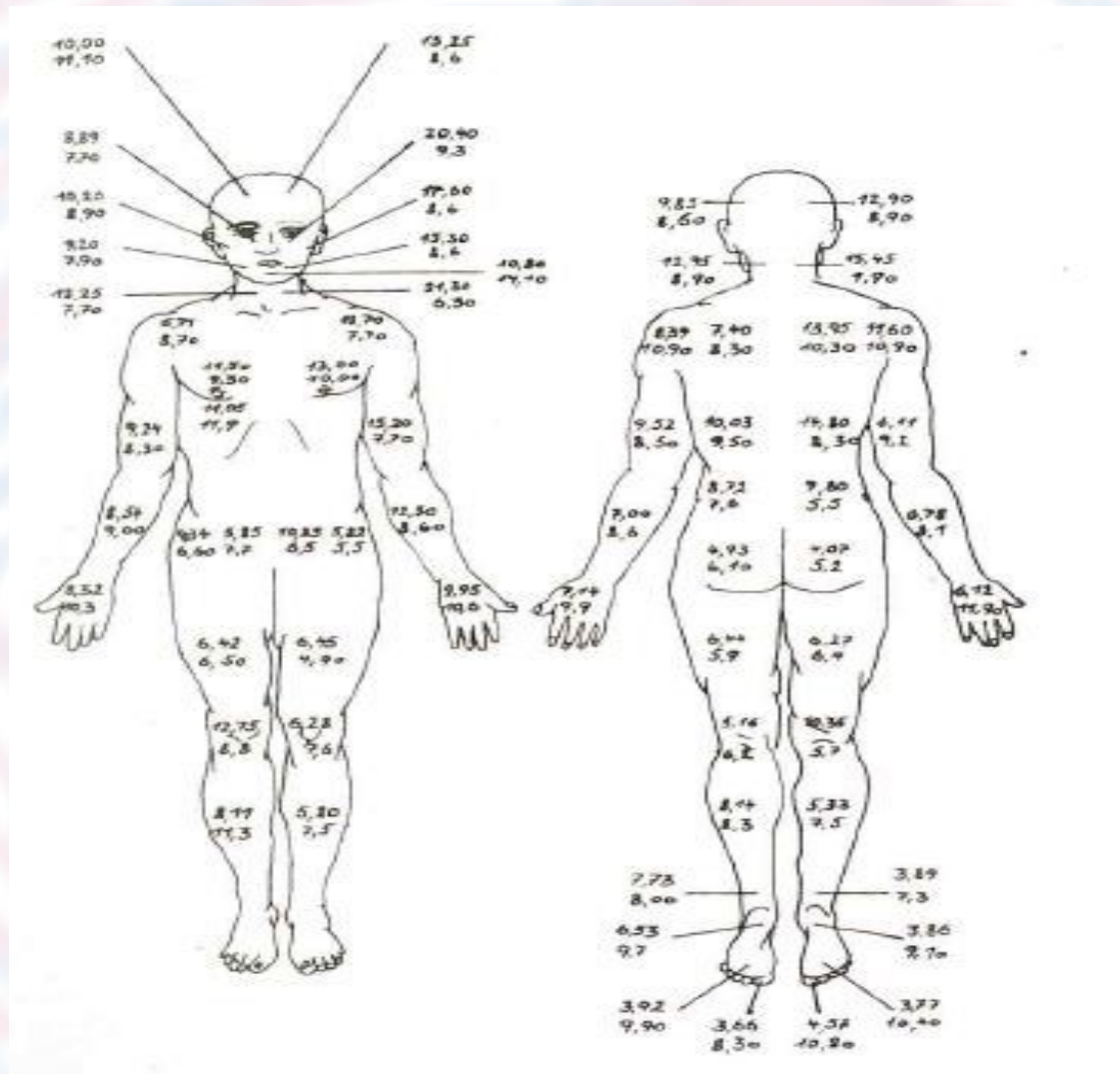Microvibration during sleep and under anesthesia,
a = state of wakefulness,

b = deep sleep (in the same person),

c = waking state,

d = anesthesia.

Rohracher&Inanaga (Microvibration, 1969)

Microvibration of Skeletal Muscles

Microvibration of various parts of the body. The numbers on the top indicate the amplitude in microns, the numbers on the bottom indicate the frequency in hertz.
Roracher&Inanaga, Microvibration, 1969

Interpretation of Skeletal Muscle Microvibration

Interpretation of microvibration from a biological point of view is possible only if the mechanism of its origin is clear. Two views have been put forward on the origin of microvibration: American authors have argued that microvibration ("normal tremor at rest") arises solely due to shaking of the body caused by cardiac activity, while Japanese authors, including myself, assumed from the moment of receiving the first registration data of microvibration that it is caused by constant muscular activity. (Rohracher&Inanaga, Microvibration, 1969)
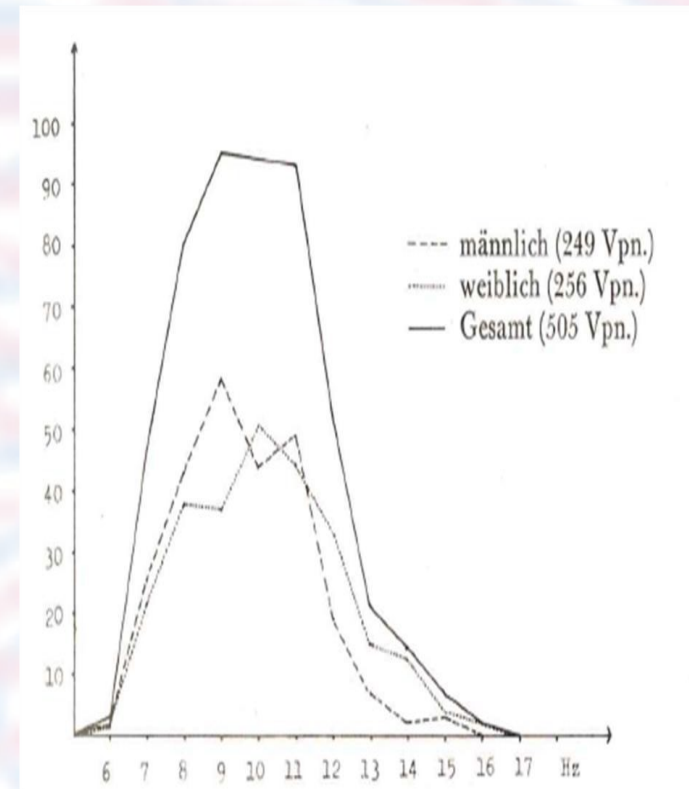
The average microvibration frequency measured in 505 people (249M and 256F) during relaxation with a Philips vibration sensor on the back of the left forearm.
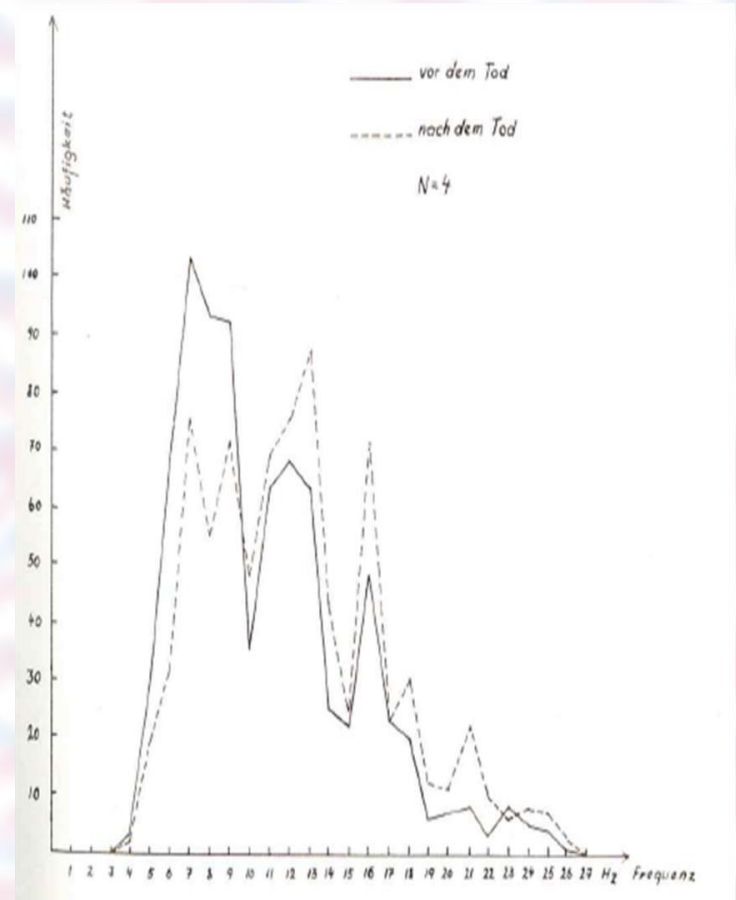
Origin of Human Microvibration

1. Cardiovascular (ballistocardiographic) hypothesis.
   The ballistocardiographic hypothesis can be summarized as covering only one microvibration component.

2. Neuromuscular hypothesis.

Research have shown that microvibration persists for 1-2 hours after clinical death.
(Rohracher&Inanaga, Microvibration, 1969)

Microvibration frequencies of 4 rabbits before and after clinical death

Theory of Alternating Contractions of Muscle Fibers

"Theory of alternating contractions of muscle fibers" can be used to satisfactorily explain both the origin of the continuous micro-movements of our body and the absence of currents of muscular action during relaxation and sleep. According to this theory, it is incorrect to talk about "resting muscles", muscles are never at rest throughout life - they continuously undergo alternating contractions of individual fibers, which together lead the whole body into a constant microtremor.

Muscle tone is not a constant low basic tension of all parts of the muscle, but the result of constantly changing individual contractions.

(Rohracher&Inanaga, 1949)

Microvibration and Constancy of Body Temperature

"Warm-blooded" means that the body is able to maintain a constant body temperature of 36.5 degrees Celsius or more; this makes warm-blooded beings largely independent of outside temperature; they remain capable of continuous action despite the change of seasons.

In all warm-blooded animals, including thick-skinned ones, microvibration was constantly detected with approximately the same frequency and amplitude as in humans, while it was absent in all cold-blooded animals:

What percentage of total musculature must always contract in order to produce enough heat to maintain body temperature at 36.5 degrees when relaxed?

2.5% of muscles constantly contracting provide 1700 kilocalories.

1 gram of muscle produces 0.003 calories per contraction, and therefore 0.03 calories per second for 10 movements; this gives 1.80 calories per minute, 108 per hour, and 2592 calories per gram of contracted muscle per day.

Body temperature is kept constant with high accuracy; this means that the muscular processes that serve to produce heat must be very finely regulated.

Microvibration Applications by Rohracher
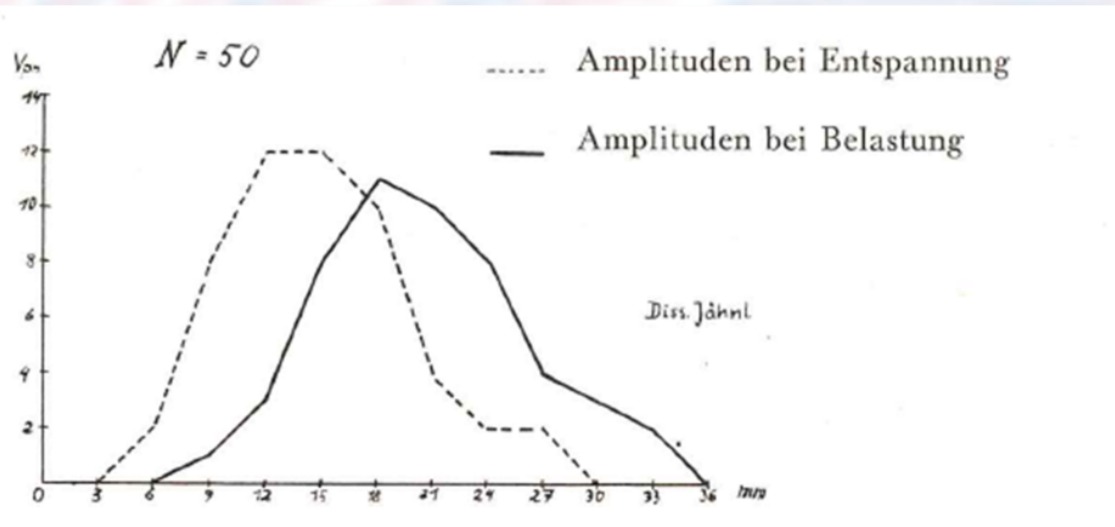
Microvibration as an indicator of psychological stress. Average vibration frequency is proportional to stress

Change in the frequency and amplitude of microvibration during the removal of gypsum in case of fractures of the hands and a decrease in pain.
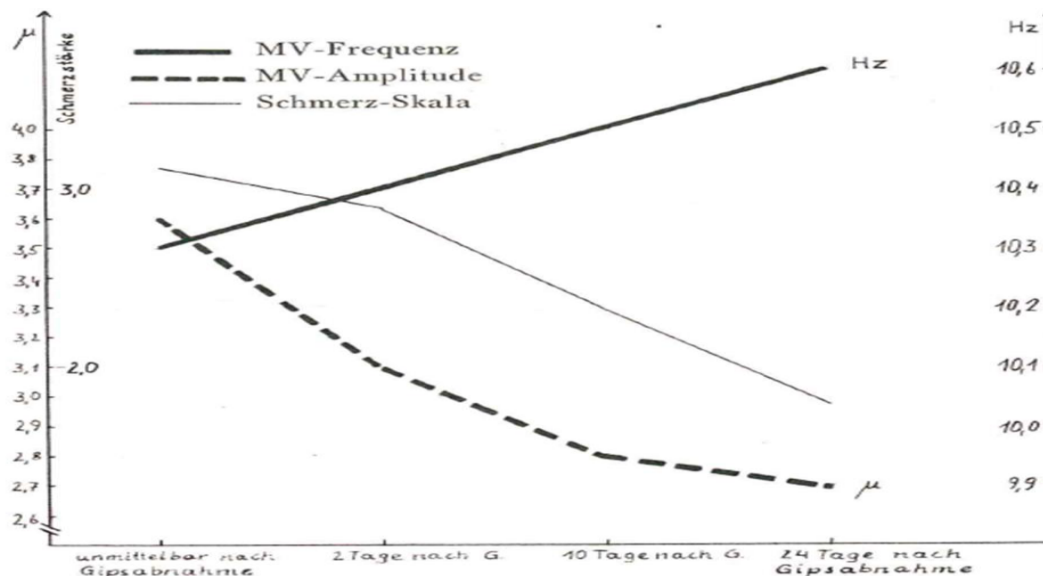
Microvibration Applications by Rohracher

Standing out among the psychological findings of MV research is the fact that microvibration can be conditioned to a certain extent (i.e., it can be turned into a "conditioned reflex" to a neutral stimulus if it was previously provided along with an appropriate biological stimulus).

Differences in microvibration between healthy people, neurotics, schizophrenics and people with brain damage.

Phylogenetic aspects
The phylogenetic aspect of microvibration is follows: if the body of warm-blooded creatures is continuously shaken, the endolymphatic fluid in the labyrinth arches of the inner ear is in constant motion, due to which the receptors located there are constantly stimulated.
"The derivation of action potentials of the vestibular nerve showed that in the <resting position> a large number of sensory cells activate continuous impulses in a steady rhythm" (Rein, 1964). These continuous excitations, the cause of which must probably be sought in microvibration, can form the basis of positional sensations of a person who is in a state of rest. (Roracher, 1969)

Conclusions about Microvibration According to Rohracher

Microvibration is a constant invisible microtremor of the body of a warm-blooded animal. Its frequency is from 1 to 18 oscillations per second with a distinct increase from 7 to 13 per second; amplitude - from 0.5 to 10 microns with the possibility of relaxation.

The cause of microvibration is continuous, alternating contractions of individual motor units distributed throughout the muscles. These alternating contractions, which occur simultaneously in many muscles, cause the whole body to make very irregular micro-movements, similar to macroscopic tremors, which never stop from birth to death.
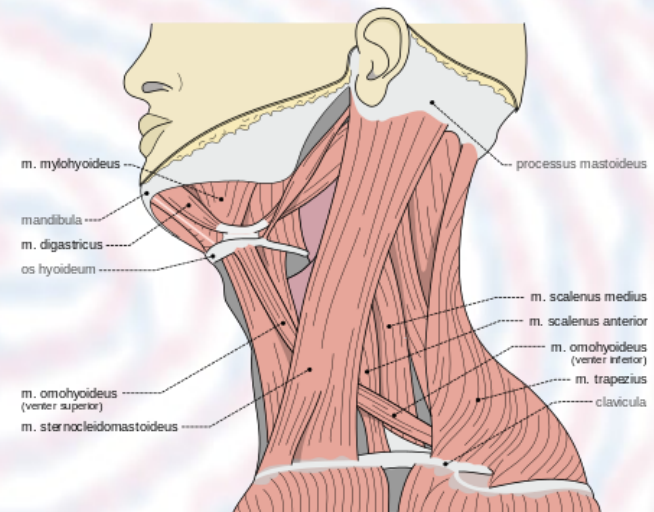
The calculation of the heat amount that can be generated by constant contractions of the muscles fibers showed that at rest only 2.5% of the total muscle mass must be in a state of constant alternating contraction in order to generate the heat necessary to maintain body temperature at a constant level.

Conclusions about Microvibration According to Rohracher

In psychological studies, microvibration amplitude has proven to be a useful indicator of mental tension and arousal. It is suitable for testing pharmaceutical relaxants.

Theoretical considerations suggest that microvibration, caused by constant oscillation of the whole body, is a long-term irritant of the endolymphatic fluid in the labyrinth and, thus, contributes to the fine regulation of balance during the movements of warm-blooded creatures.

The use of microvibration (MV) in pharmacology

Anesthetics. All anesthetics decrease MV amplitude and reduce frequency.

Tranquilizers. Chlorpromazine inhibits MV in many cases.

Relaxants. MW is inhibited by relaxants.

Antiepileptic drugs. The introduction of medium doses of antiepileptic drugs does not have a clear effect on MV.

The effect of drugs on human MV

Frequency analysis of MW. Alcohol strengthens the theta group; sleeping pills, drugs or muscle relaxants suppress CF. Adrenaline increases theta group.

Treatment of Schizophrenia with Microvibration Control
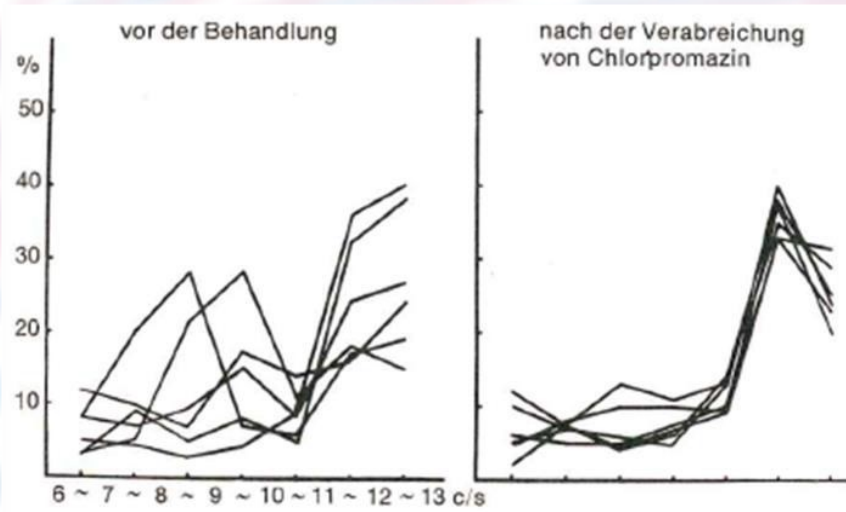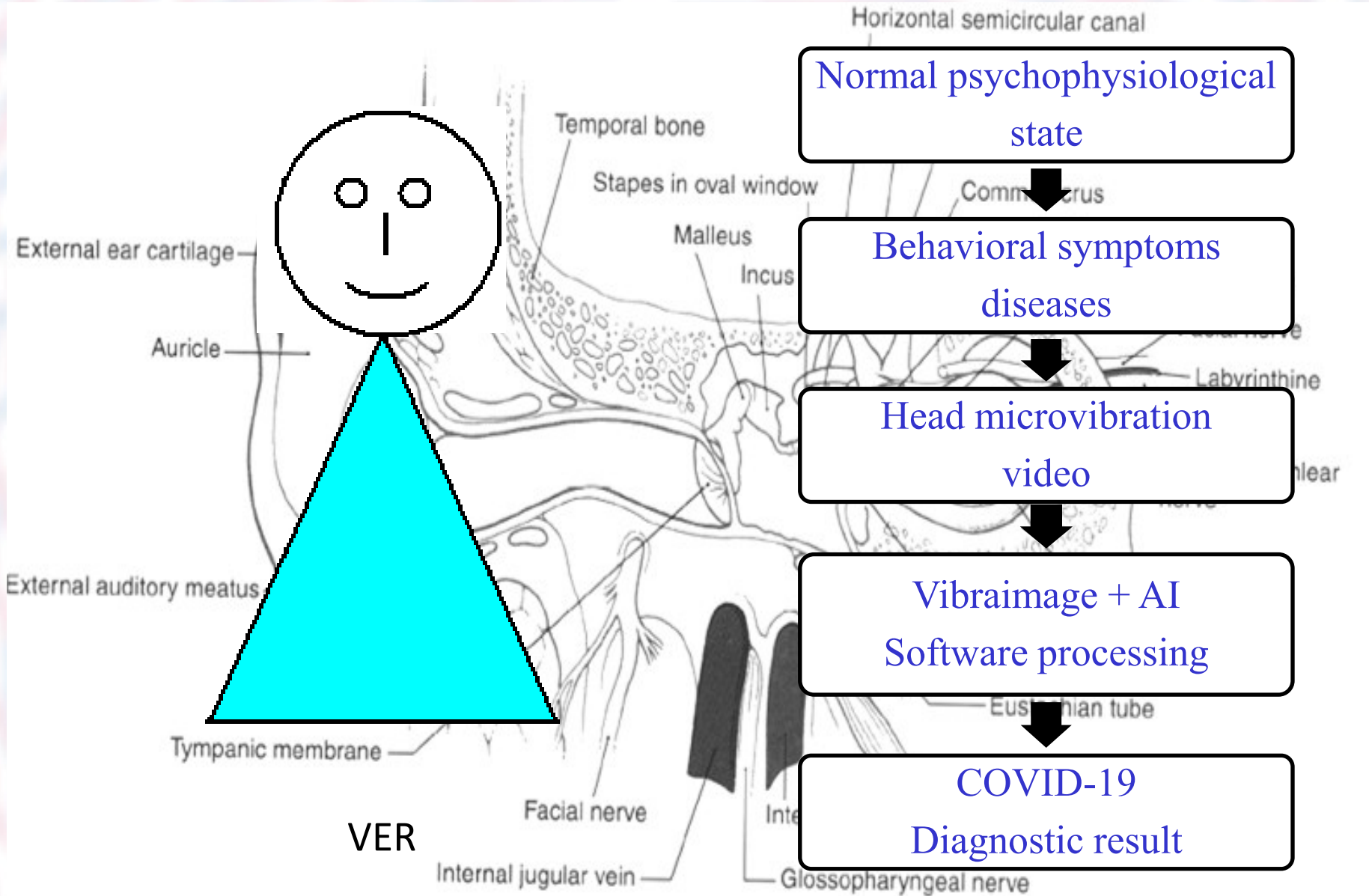

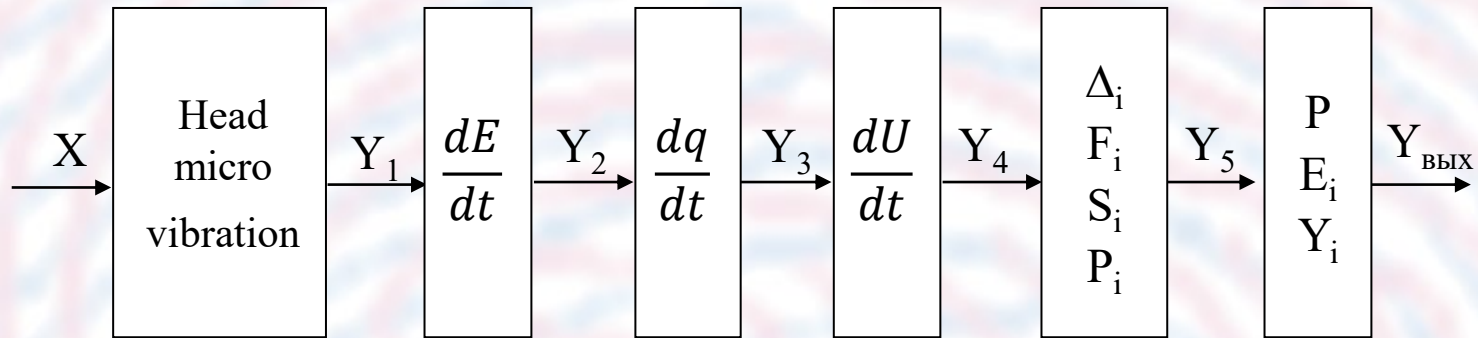6 cases of CF with successful treatment Rohracher&Inanaga, 1969
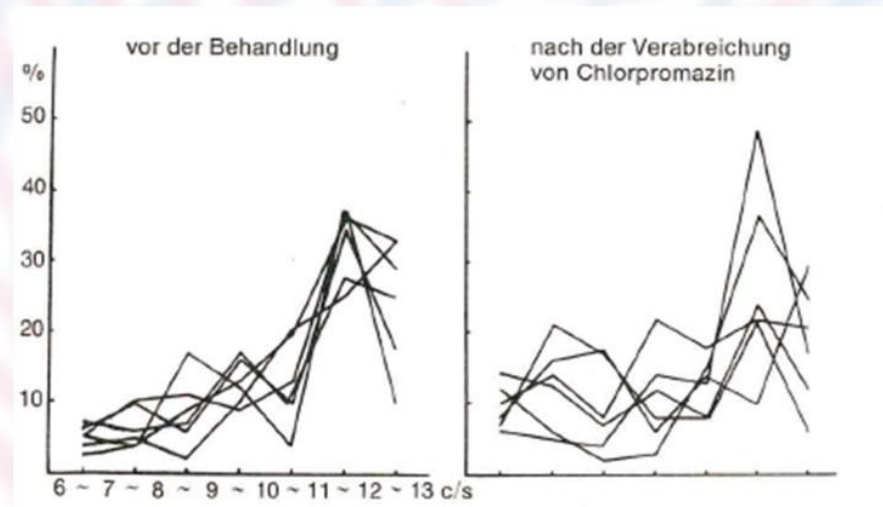
6 cases of CF with ineffective treatment Rohracher&Inanaga, 1969

Vestibulo-Emotional Reflex (VER)

Normal psychophysiological state

↓

Behavioral symptoms diseases

↓

Head microvibration video

↓

Vibraimage + AI Software processing

↓

COVID-19 Diagnostic result

VER

Vibraimage Systems of the First Generation. Direct Conversion Measuring Instruments

$$X \rightarrow \boxed{\begin{array}{c} \text{Head} \\ \text{micro} \\ \text{vibration} \end{array}} \xrightarrow{Y_1} \boxed{\dfrac{dE}{dt}} \xrightarrow{Y_2} \boxed{\dfrac{dq}{dt}} \xrightarrow{Y_3} \boxed{\dfrac{dU}{dt}} \xrightarrow{Y_4} \boxed{\begin{array}{c} \Delta_i \\ F_i \\ S_i \\ P_i \end{array}} \xrightarrow{Y_5} \boxed{\begin{array}{c} P \\ E_i \\ Y_i \end{array}} \xrightarrow{Y_{\text{вых}}}$$

Block diagram of vibraimage system for direct measurements.

X − PPS characteristics,

Y_1 − change in the light flux depending on the contrast of the object and its motor activity,

Y_2 − spatial transformation of the light flux using the optics of a   television camera,

Y_3 − charge conversion in the photodetector,

Y_4 − analog-digital signal-to-digital conversion,

Y_5 − primary parameters of vibraimage,

Y_{out} − PPS characteristics measurement result.

Basic Parameters of Vibraimage System of the First Generation

- Amplitude   Ai-A6

$$A(1,2,3) = \frac{1}{Cn} \sum I_i$$

- Frequency   Fi- F12

$$F(1,2,3) = \frac{255}{Ca} \sum I_i \neq 0\,?1:0$$

- Symmetry   Si-S7

$$S(1,2,3) = \frac{S_L - S_R}{Cn}$$

- Processing   Pi-P30

$$P(1,2) = \sqrt{\frac{1}{n} \sum_1^n (\max RL_i - CM)^2}$$

- Behavioral   E1-E16

$$E1 = Ag = \frac{F_m + 4 * \sqrt{\frac{1}{n} \sum_1^n \left(F_i - \overline{F}\right)^2}}{2F_{in}} = \frac{F_m + 4\sigma}{2F_{in}} \cdot 100\%$$

- Systemic   I; E; P; M; SD

Behavioral Parameters as Characteristics of Head Microvibration Having Minimal Correlation

	M	SD	Vi (S/M)	C
(P1) Aggression	38,28	5,50	14,36	0,56
(P2) Stress	35,50	8,32	23,44	0,58
(P3) Tension	34,99	5,17	14,78	-0,27
(P4) Suspect	36,25	5,07	13,99	0,68
(P5) Balance	45,41	9,81	21,61	-0,1
(P6) Charm	65,36	7,75	11,85	-0,32
(P7) Energy	10,66	4,87	45,70	0,41
(P8) Self-Regulation	54,27	7,48	13,78	0,81
(P9) Inhibition	18,04	3,90	21,60	-0,48
(P10) Neuroticism	38,97	8,64	22,16	-0,43
(P11) Depression	43,61	7,90	18,11	0,54
(P12) Happiness	28,24	5,42	19,18	0,39

+ I, E, P; C; - 68 behavioral parameters measured at 10 fps

Vibraimage System of the 4th Generation. Application of AI and ANN

AI training
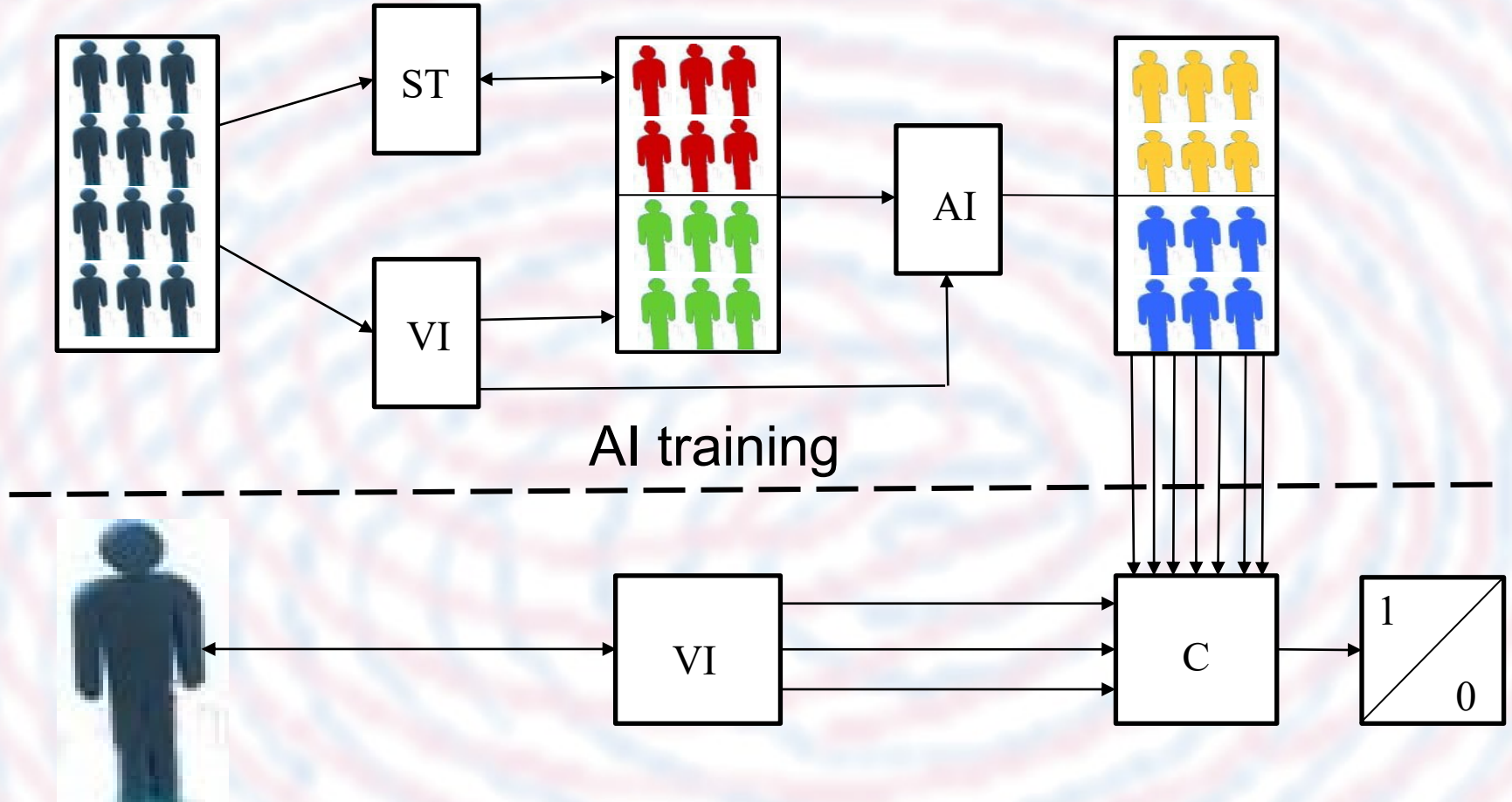
Measuring Behavioral Parameters by VI+AI
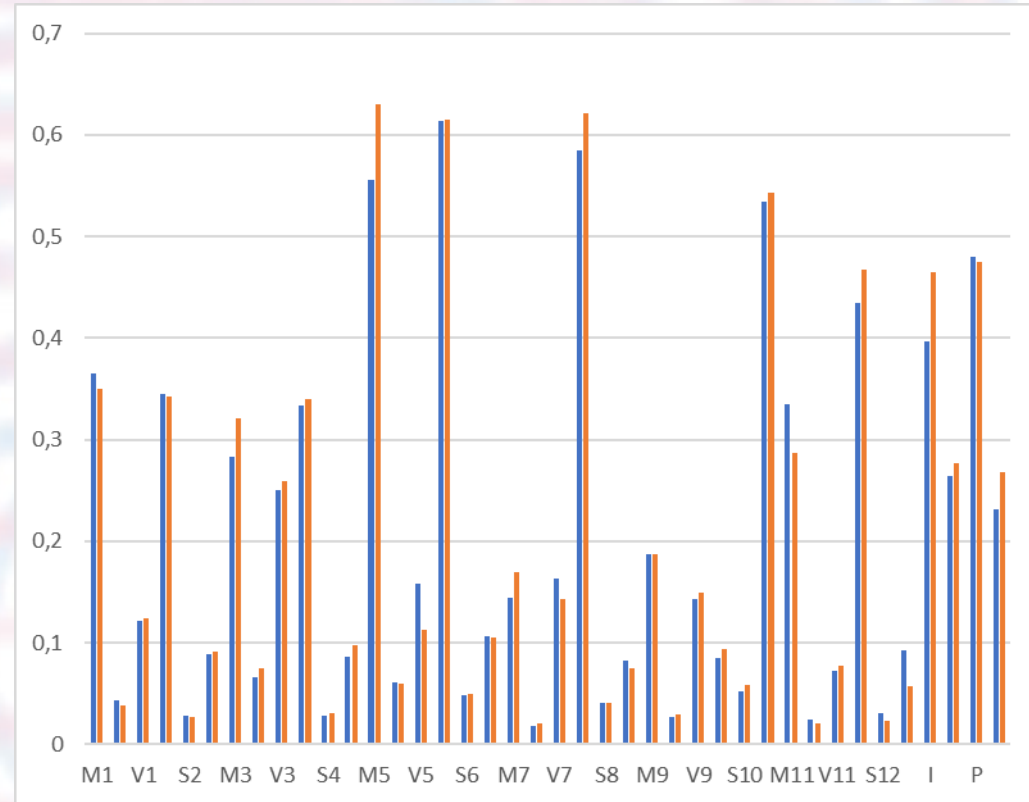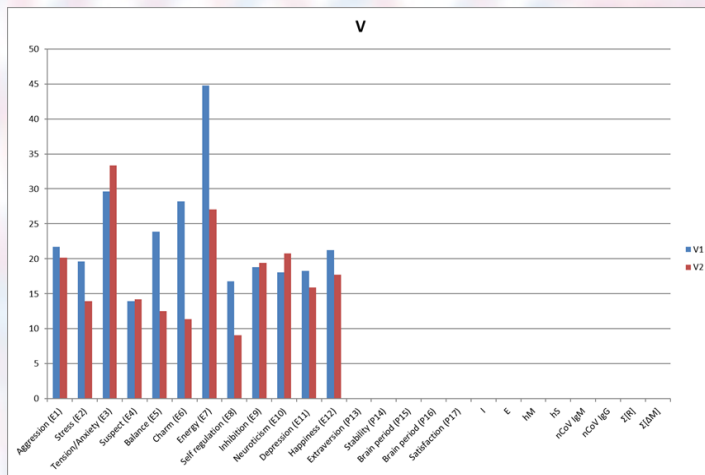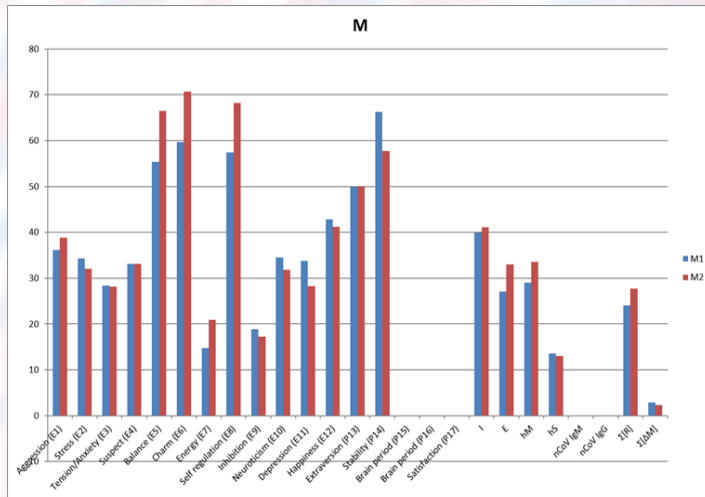
Variability for Behavioral Parameters
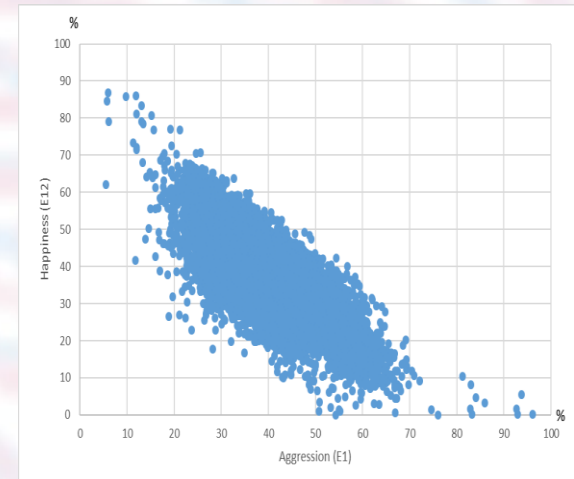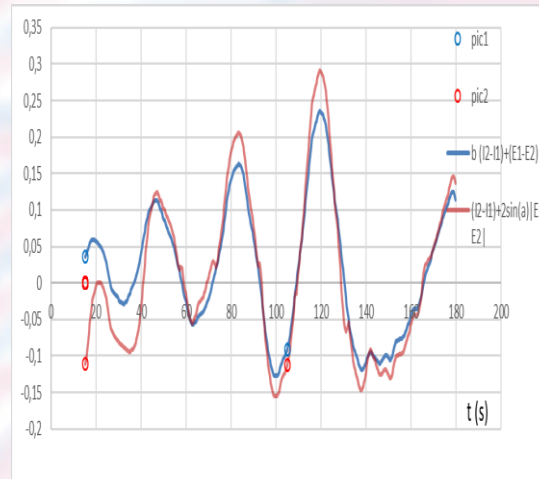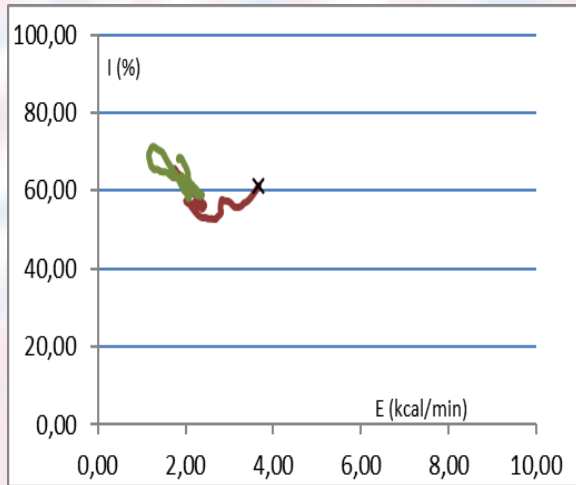
Без предъявления внешних стимулов
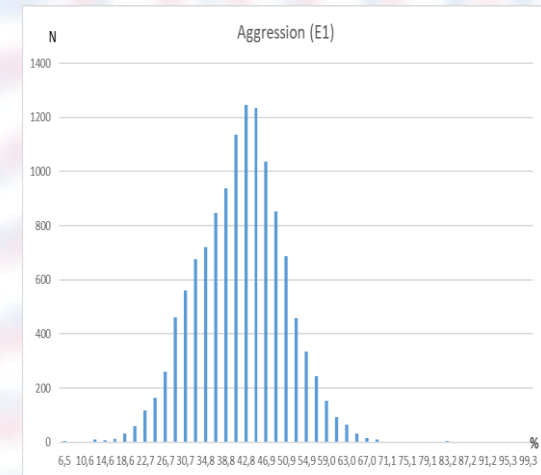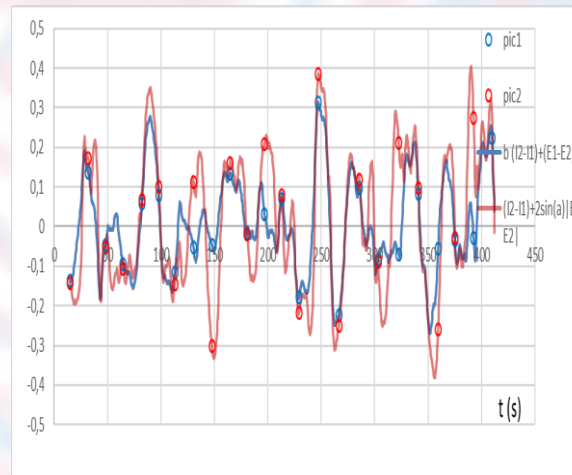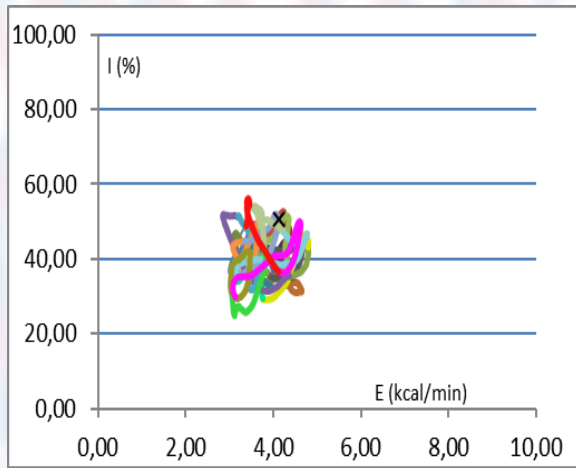
При предъявлении внешних стимулов

Mean and Instant Values of Behavioral Parameters for COVID-19 Diagnosis

Comparison of Patients and Controls based on BP mean values

Comparison of Patients and Controls based on instant BP values
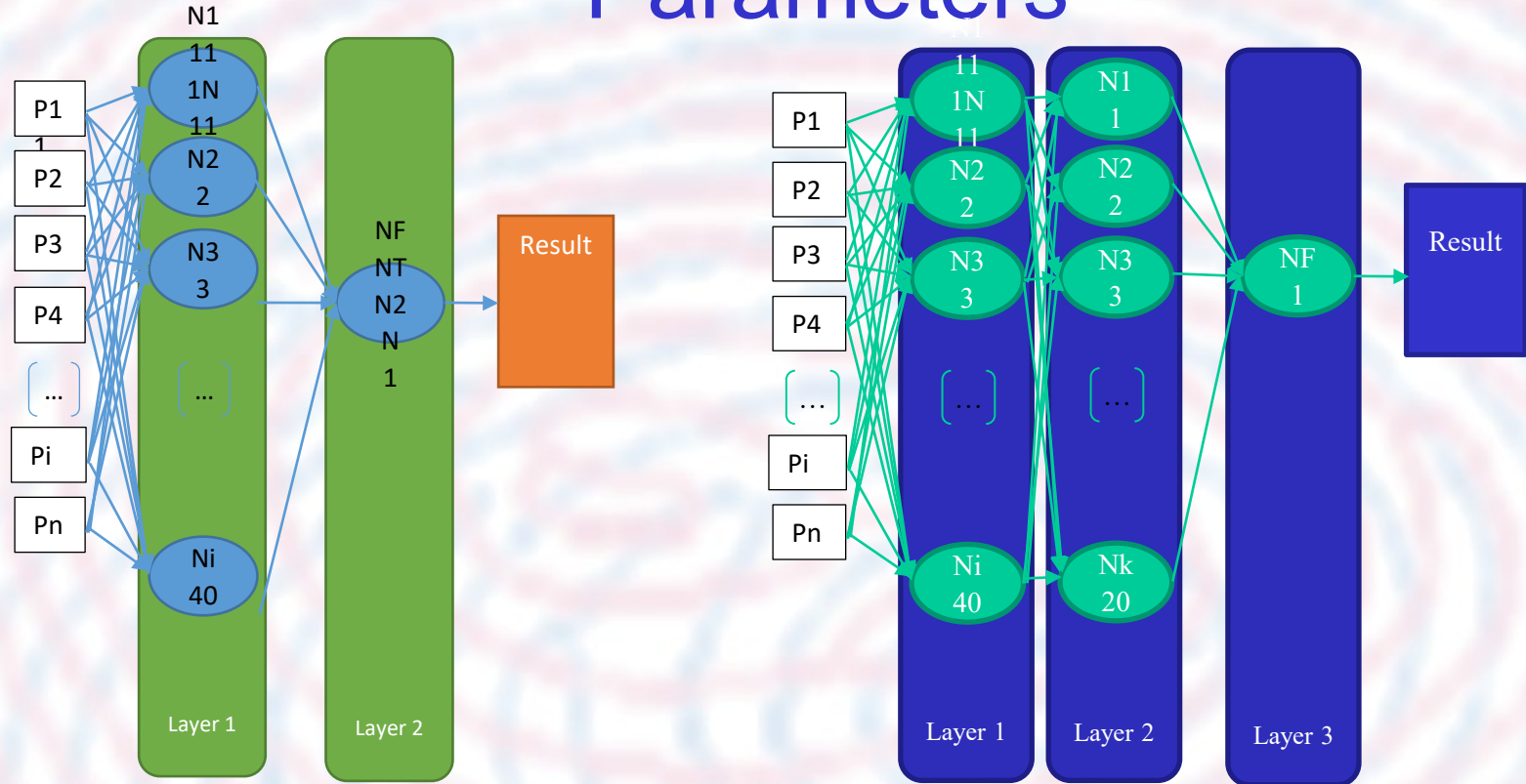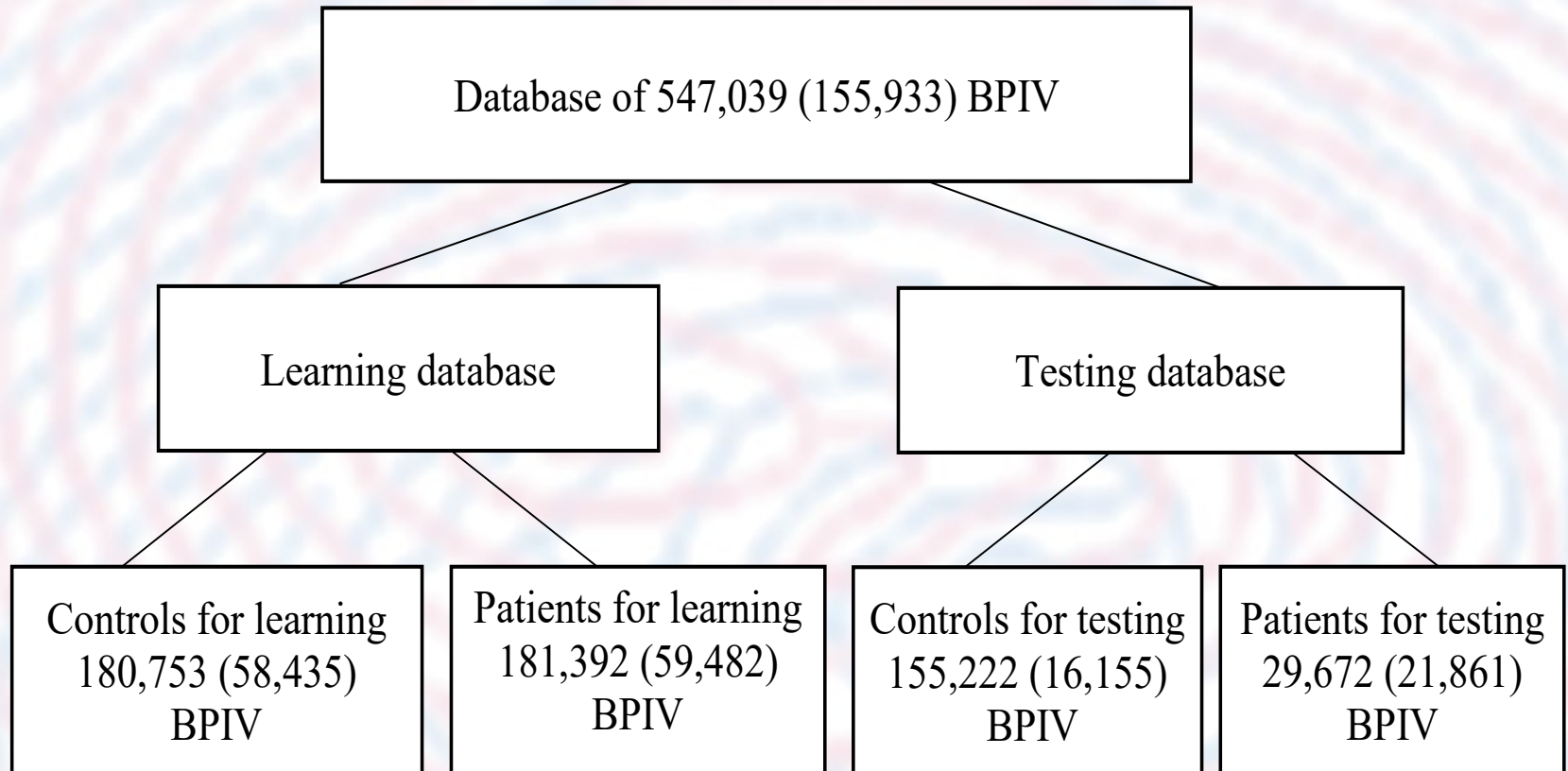
# ANN Training Structure by Behavioral Parameters

Fig. 1. *Block diagrams of linear neural networks with feedforward for discrimination of databases in two groups: patients and control, a) – the simplest feedforward network; b) – a feedforward network with one hidden layer of neurons.*

Databases and ANN Testing Format

BPIV database structure used for AI learning and diagnosis accuracy testing. Preliminary study database size given without (). Basic study database size given in ().
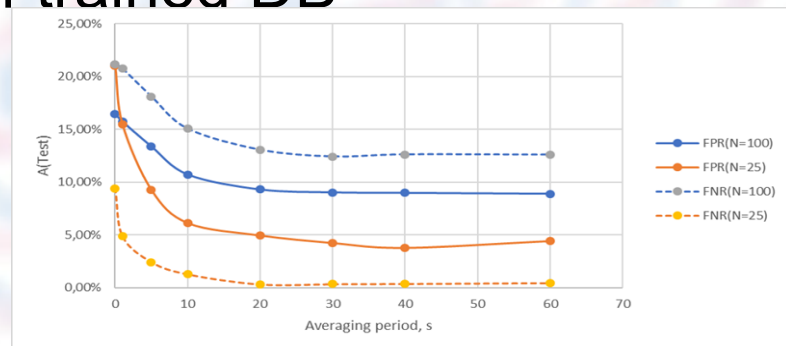
COVID-19 Diagnostic Accuracy by VI+AI
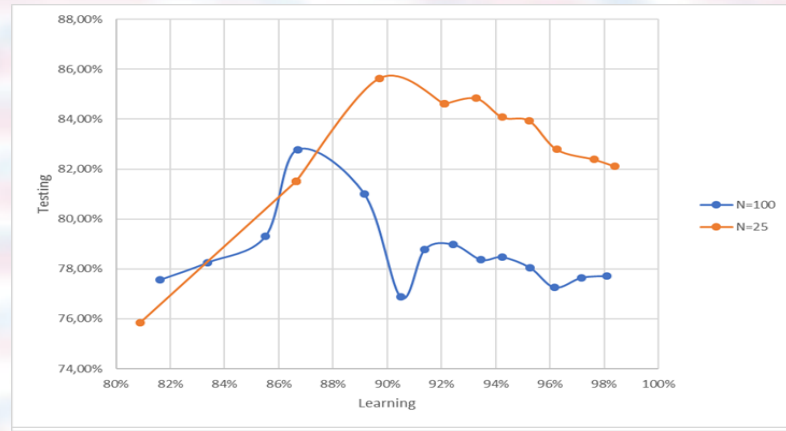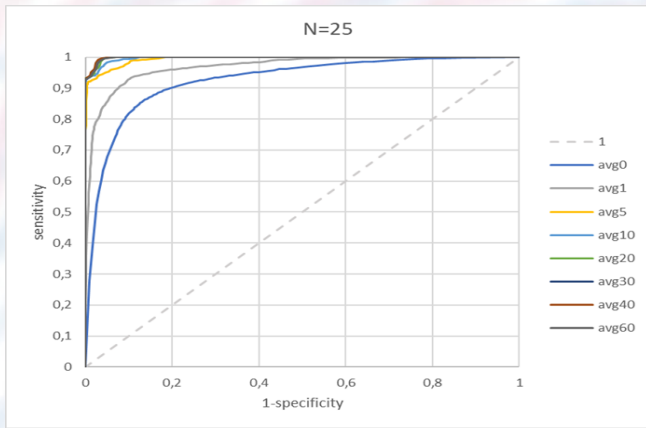
ROC dependency diagnostic sensitivity-specificity

Dependence of test DB diagnosis accuracy on discrimination accuracy of trained DB
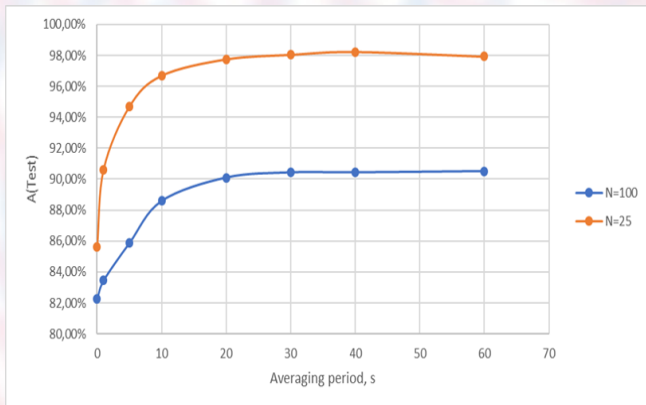
Dependence of accuracy on integration time of diagnostic result for (N=100) and (N=25).


Dependences of errors on the integration time of the diagnostic result for (N=100) and (N=25).

Principles for Improving the Accuracy of Diagnosing Diseases

- **Discretization.** The frequency of video conversion to vibraimage parameters should be maximum at the minimum level of video image noise.

- **Conformity.** The time of accumulation of the interframe difference should coincide with the period of the analyzed physiological process.

- **Optimality.** The number of measured behavioral parameters should be minimally sufficient for the analysis of the studied physiological process or response to the presented stimulus.

- **Infinity.** Vibraimage technology allows extracting any amount of biometric information about the object under study from a video image.
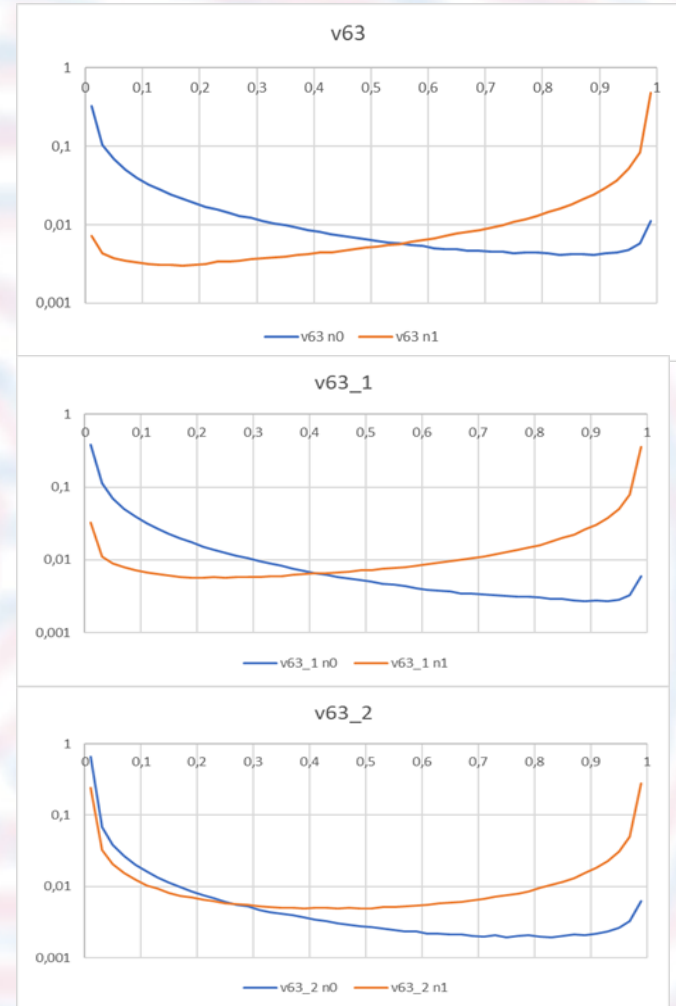
Determining the Stage of a Disease
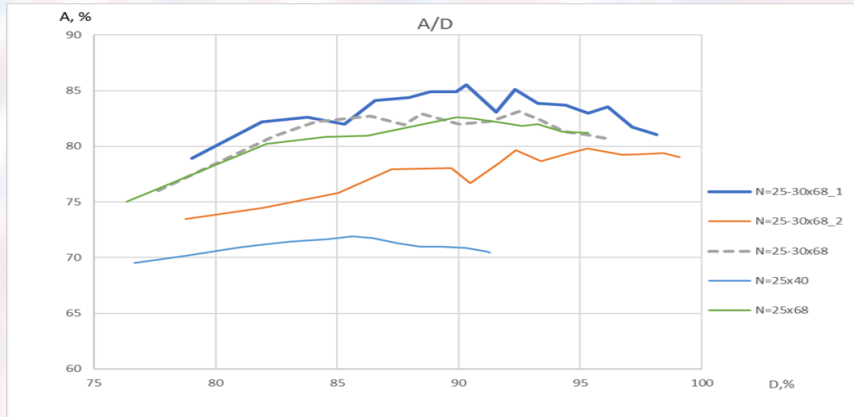
Dependence of instant diagnosis accuracy of testing database A on the discrimination accuracy of training database D
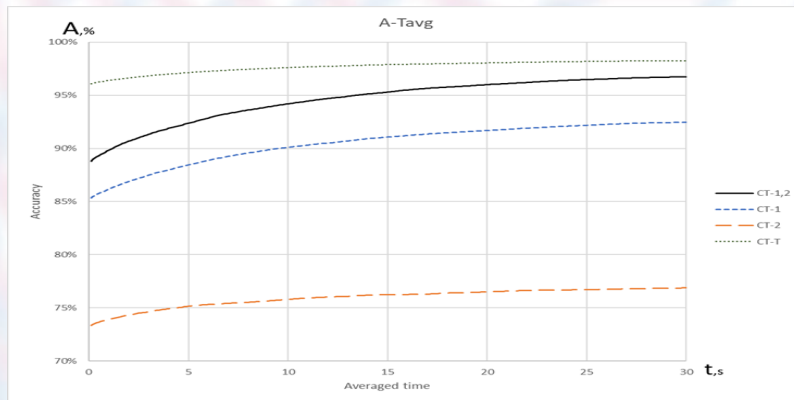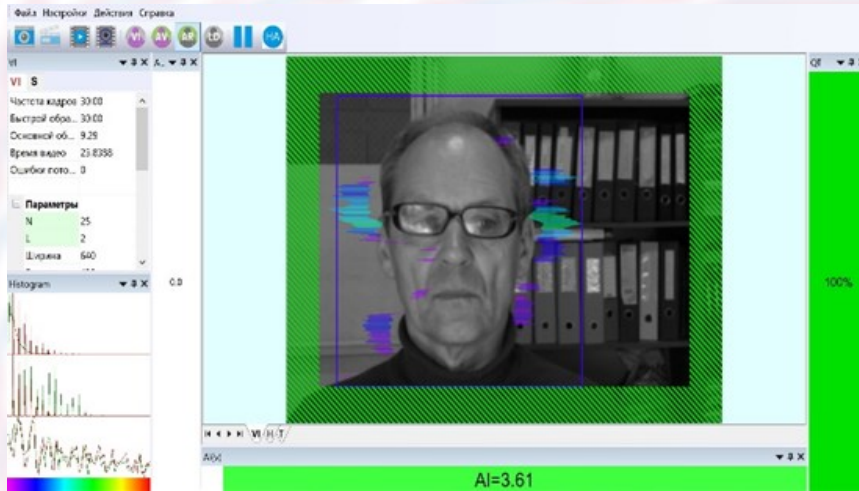

Calculation of experimental and theoretical accuracy of diagnostics according to the equation;
$$A_{CT-T} = 1 - (1 - A_{CT1}) \times (1 - A_{CT2})$$

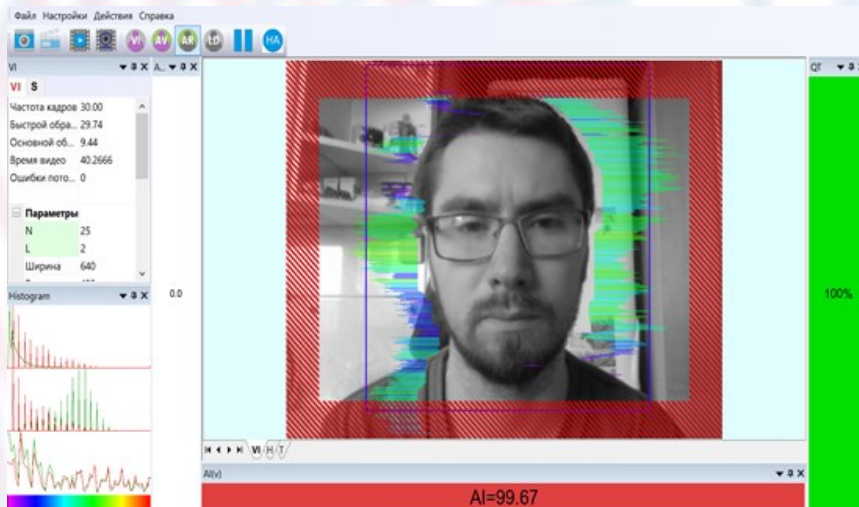Errors density on different stages of COVID-19

27

Medical Research of the Contactless Method of COVID-19 diagnosis. Covid5s Software
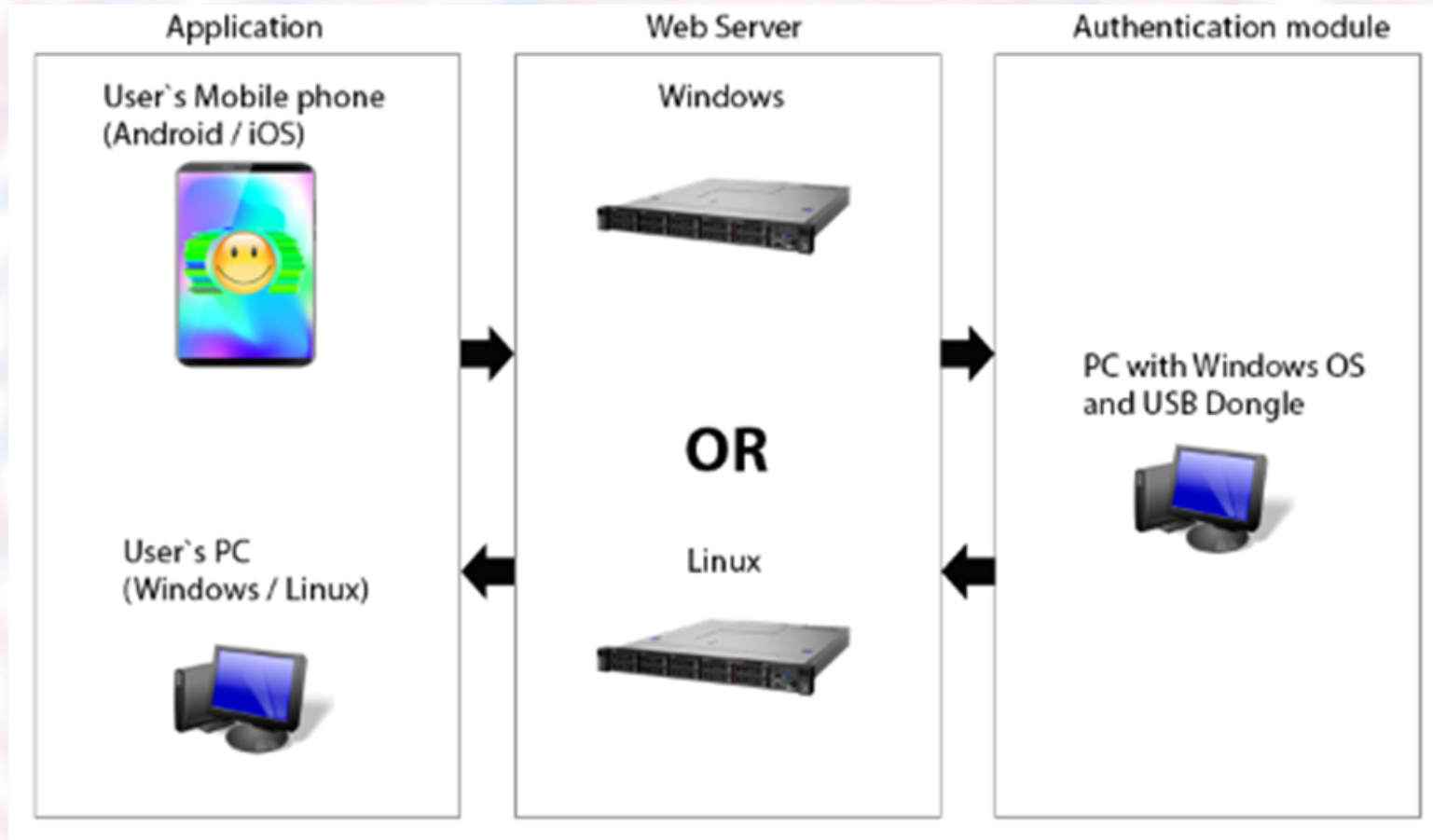

Negative diagnostic result COVID-19. Software Covid5s

Positive diagnostic result COVID-19. Software Covid5s

Contactless COVID-19 Diagnosis by Mobile Devices

Various structures and OS used for contactless diagnostics of COVID-19.

Future for Dangerous Diseases Diagnosis

Contactless auto diagnosis of diseases should have
wide application all over the world!

The Main Problems of Contactless Diagnostics of Diseases

Medical distrust of contactless methods for diagnosing diseases.

Distrust of decisions made by AI regarding to a person.

Distrust of modern medicine to behavioral parameters as clinical symptoms of the disease.

Distrust of Russian innovative technologies.

Lack of statistically confirmed results of clinical trials conducted in accordance with ISO 14155-2014.

The Main Advantages of Contactless Diagnostics of Diseases

Contactless method and the possibility of auto diagnostics eliminates the possibility of infection of personnel in the diagnosis of infectious diseases.

Rapid AI training with a database of standard patient and control group videos.

The possibility of using a single database of the control group for the diagnosis of various diseases.

The speed of diagnosis of diseases and the ability to detect the disease at an early stage of development before the appearance of visible symptoms of the disease.

Open algorithms for checking the accuracy of diagnosing diseases and the possibility of creating open databases for diagnosing diseases using the example of COVID-19
https://psymaker.com/downloads/NN3.zip

Conclusion

1. Contactless method for COVID-19 diagnosis, despite the fantastic simple implementation, is based on a scientific approach to the analysis of reflex movements, statistically confirmed and has proven its practical feasibility.
2. Head motion video processing is not limited to PC processing, the next obvious step is to bring this technology to mobile phone platforms.
3. The original databases of diagnostic results are made publicly available in additional materials, allows independent developers to refine their COVID-19 diagnostic algorithms based on the available results.
4. Operational 5-20-60-second video testing of COVID-19 protects against the spread of the pandemic more reliably than QR codes and vaccination passports, since real-time diagnostics of COVID-19 provides more guarantees of health than formal documents, that do not confirm the absence of infection.
5. Contactless technology for diagnosing COVID-19 has created the prerequisites for the successful diagnosis of different infectious and non-communicable diseases.

Thank you for the attention!

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