Traditional medicine of three regions of Russia and the use of information technologies to investigate it

V V Boronoev & N V Pupysheva[*]

Laboratory of Wave Diagnostics of Living Systems of the Institute of Physical Materials Science of the Russian Academy of Sciences
(Siberian Branch), Sakhyanovoi Str., 6, 670047 Ulan-Ude, Republic of Buryatia, Russian Federation

[*]E-mail: pnv21@yandex.ru

The paper presents experience of investigating the traditional medicine for the three regions of Russia – Buryatia, Kalmykia and Tuva — that has been kind of folk tradition here for centuries. This is Tibetan medicine that is the cultural and historical heir of the Indian medical tradition using some elements of the Chinese medicine. The paper gives information on the problem of objectifying and automating the Tibetan diagnostic methods (inspection, palpation, questioning) using information technologies. This research has been carried out in two directions: objectification and automation of pulse diagnostics by the development of the Computer Pulse Diagnostic System and the development of the Expert Diagnostic System for questioning and inspection of a patient. On the basis of the assessments of the experts (specialists in pulse diagnostics) and mathematically detected diagnostic signs of pulse waves, statistical models of normal and pathological pulses (pulses of «hot» and «cold» diseases) have been developed. A catalogue of pulses is being compiled. This catalogue consists of classes of computer recorded pulse signals that correspond to Tibetan nosology. The expanded and differentiated catalog of pulses and the pulse wave pattern recognition program designed to compare measured pulses and reference pulses will make the basis for combining the diagnostic results by three diagnostic methods, which will lead to the creation of an Integral Computer Diagnostic System designed for diagnosing diseases and providing recommendations for health correction in accordance with the traditions of Tibetan medicine.

The tradition of Tibetan medicine *Sowa Rigpa* («*science of healing*») is a significant component of Tibetan Buddhist culture that came to three *Russian Republics* (*Buryatia*, *Kalmylia* and *Tuva*) together with the spread of Buddhism in these regions centuries ago. Historically and culturally, Tibetan medical tradition inherited the basic principles of the Indian Buddhist tradition, besides it used some aspects of Chinese medicine.

Currently, Tibetan medicine is studied by modern scientists because in many cases its methods of diagnostics and treatment have shown validity and great informative value. The diagnostic methods are studied by physicists because these methods have real physical foundation. Pulse diagnostics of Tibetan medicine is of special interest to physicists. The present article shows attempts to use information technologies for examining pulse diagnostics, as well as the other diagnostic methods. Similar attempts are being carried out in the Oriental countries — India, China, etc.[1-3]; scientists in the West find interest in the Oriental medical traditions and are trying to use the oriental methods, alternative to western scientific medicine, as complementary ones[4].

Before discussing the use of information technology for pulse diagnostics, it is essential to recall a few basic items of the theory of Tibetan medicine: the systems of «*great elements*» (*Skr. mahabhūta, Tib. 'byung pa chen po*) and four *dhātu* (*Tib. khams* — basis, element); the three damaging factors (*Skr. dosha*; *Tib. nyespa*); the concepts of «heat» and «cold»; the traditional palpation points on the radial arteries (*Tson*, *Kan*, *Chag*) connected with 12 internal organs; the place of pulse palpation, the measure of pressure on the palpation points, and so on.

According to the views of Tibetan medicine, every sentient being and entire outer world consist of *five primary elements — earth* (*Skr. pṛthivi*; *Tib. sa*),

water (*Skr.* apas; *Tib. shu*), wind (*Skr. vāyu; Tib. rlung*), fire (*Skr. agni; Tib. me*), and space (*Skr.* ākāśa; *Tib. nam mkha'*). This system of primary elements is of Indian origin (*mahabhūta*) that has fundamental character because entire Buddhist philosophy is based on it. However, Tibetan medicine also uses the system of primary elements of Chinese origin (*huǒ* – fire, *tǔ* – earth, *jīn* – metal, *shuǐ* – water, *mù* – wood). In Tibetan medicine, this system of primary elements is used to designate the *dhātu* — the places in a human body where the *mahabhūtas* manifest themselves (the internal organs, the body constituents, etc.).

On the level of physiology, five *mahabhūtas* take the form of three «damaging factors», or three psycho-physiological systems of an organism (*Skr. doṣa; Tib. nyespa* — lit. «guilty ones», «faults»). These are *rLung* (*Skr. vāta*), *mKhrispa* (*Skr. pitta*), *Badkan* (*Skr. kapha*). The nature of *mahabhūta rLung* (*wind*) is movement, which is also the nature of *nyespa rLung*; *mKhrispa* is the embodiment of the *mahabhūta fire* (*me*); *Badkan* is the combination of the *mahabhūtas water* (*shu*) and *earth* (*sa*)[5-7]. These *nyespas* are united in two groups — that of «heat» and that of «cold». Actually, *mKhrispa* has the nature of *fire*; that is why it represents the features of «heat». *Badkan* embodies the properties of *water* and *earth*; that is why it represents the features of «cold». The nature of *rLung* is also «cold». However, it is defined as movement; that is why it accompanies both *mKhrispa* and *Badkan*[5,8].

The place of pulse palpation is the six traditional points on the radial artery of both wrists of a patient. These points are *Tson*, *Kan* and *Chag* where the pulses of 12 internal organs can be palpated and analyzed. These points are located on the radial artery at a short distance from each other, starting about 3 cm from the low end of the palm. Point *Tson* on the left wrist is responsible for the heart (living organ) and small intestine (hollow organ); point *Tson* on the right wrist is responsible for lungs (living organ) and large intestine (hollow organ), which is true for men. For women, this order is inverted. At point *Kan* on the left wrist, the pulse of spleen (living organ) and stomach (hollow organ) can be felt. At point *Kan* on the right wrist, the pulse of liver (living organ) and gall bladder (hollow organ) can be palpated. At point *Chag* on the left wrist, the pulse of left kidney (living organ) and genitals (hollow organ) can be felt. At point *Chag* on the right wrist, the pulse of right kidney (living organ) and urinary bladder (hollow organ) can be felt.

The measure of pressure on the palpation points is very important. The pressure on the *Tson* points should be light; the pressure on the *Kan* points should be medium; the pressure on the *Chag* points should be the strongest[5,6].

Methodology

Definition of the problem

Comprehensive studies of the problem of a technical approach to pulse diagnostics of Tibetan medicine have been carried out in the Laboratory of Wave Diagnostics of Living Systems of the Institute of Physical Materials Science of the Russian Academy of Sciences (Siberian Branch). The approach to the problem has an interdisciplinary character because it requires a wide range of investigation of the theory of Tibetan medicine for physiological and physical interpretation of the basic issues of pulse diagnostics and for creating computer diagnostic systems.

Traditionally, diagnosis is made solely on the basis of the data obtained with the help of a doctor's senses, as well as the doctor's skills, which require a lot of knowledge and many years of experience. Only a combination of these two factors allows a Tibetan medical doctor to recognize diseases with sufficient reliability. Otherwise, the subjective method can lead to misdiagnosis and to inadequate treatment. In other words, diagnostics in Tibetan medicine is, on the one hand, a special kind of art, and on the other hand, it is a carefully developed and systematized method of recognizing diseases.

Siberian scientists are working on the problem of objectifying and automating the diagnostic methods of Tibetan medicine (inspection, palpation, questioning) in two directions: 1) objectification and automation of pulse diagnostics — the development of the Computer Pulse Diagnostics System (*CPDS*) and 2) the development of the Expert Diagnostic System (*EDS*) for diagnostics by the methods of questioning and inspection.

The ultimate goal of the research is the creation of an Integral Computer Diagnostics System of Tibetan medicine that is going to integrate the Computer Pulse Diagnostic System (*CPDS*) with the Expert Diagnostic System (*EDS*).

Materials and Methods

The structure of the pulse diagnostics device and its software

The technical basis of the Integral Computer Diagnostics System is the Computer Pulse Diagnostic System (*CPDS*) of Tibetan medicine.
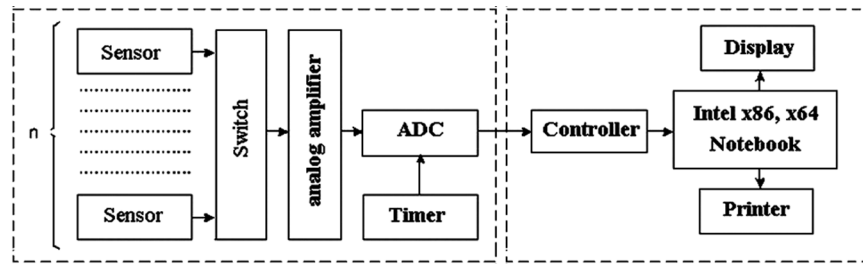
Fig. 1 — Block-Scheme of the CPDS

The *CPDS* was developed in collaboration with the International Institute of Tibetan-Mongolian Medicine (*IITMM*, *Ulan-Ude*) and the Plant of Radio-Electronic Medical Equipment «*REME*» (*Lviv*, *Ukraine*). Manufacturing and calibration of the electronic part of the pulse diagnostics system and of the pulse sensors were carried out at the test benches of the department of medical sensors of the «*REME*» plant.

The block- scheme of the basic version of the Computer Pulse Diagnostic System (*CPDS*) that is used to study pulse diagnostics of Tibetan medicine, is presented in Figure 1.

The analysis of biomedical data is carried out according to the following scheme: 1) scanning the sensors with a set frequency; 2) preliminary or complete data processing and information recording; 3) decision-making based on the hypothesis embedded in the program.

The basic version of the *CPDS* is based on polycardiographic[9] and polysphygmographic[10] methods of research. Therefore, the pulse diagnostics device makes it possible to simultaneously register and process signals obtained and recorded using the standard sensors, — signals of electrocardiogram (*ECG*), phonocardiogram (*PCG*), velocity kinetocardiogram (*KCG$_{ve}$*), sphygmogram of the carotid artery (*SPG$_{ca}$*) and six sphygmograms (pulsograms) of the radial arteries (*SPG$_{ra}$*). A computer display is used as a visual control device for input signals from the sensors.

The main technical component of the *CPDS* pulsogram recorder is the piezoceramic pulse sensors (Fig. 2). This is a multi-zone device for registering pulsograms with uneven amplitude-frequency characteristics (*AFC*) in the frequency range (0.5–30) Hz not exceeding 2.5%, with sensitivity (12.8±3) mV/Pa and with the identity of six channels of pulsograms registration ~ 95%. The reproducibility of measurement results is ~ 90%.

The pulse sensors are constructed to be able to regulate the pressing force of the pulse sensors on the

Fig. 2 — Pulse sensors (2 sets of three sensors) for registering sphygmograms (pulsograms) of the radial artery

radial arteries of both wrists in accordance with the requirements of the pulse diagnostic method as it was mentioned above (see: Introduction).

The pulse sensors are applied to the traditional palpation points. The first palpation point *Tson* is located on the radial artery between the distal end of the radial bone and its diaphysis; the second sensor is installed on the *Kan* point; the third sensor is applied to the *Chag* point. The distance between the centers of the sensors should be 2 cm. The clamping force of each sensor is regulated and controlled by the maximum amplitude of the pulse wave and increases from the first point to the third one due to an increase in the depth of the radial artery, which allows taking into account the anatomical feature of the location of the radial arteries on both wrists. The duration of pulse signals measurements for instant assessment of the state of the internal organs ranges from 20 to 100 pulse beats. However, depending on the situation, this time may vary.

The *CPDS* software provides complete and transparent control of the *CPDS* hardware, visual presentation of recorded signals and analysis of pulse waves. The calculation outcomes are given immediately, and can be interpreted by the doctor who is doing the diagnostics. The decision support

system (*DSS*) uses both the knowledge base and the results of the pulse signal processing, which provides a preliminary assessment of the functional state of twelve internal organs in an automatic mode. Taking into account the conclusion of the *DSS*, the doctor makes a definite diagnosis according to the method and in terms of modern scientific medicine.

Assessment of the quality of pulse signals registration using the CPDS

According to the pulse curves recorded at three traditional palpation points, *Tson*, *Kan* and *Chag*, shown in Figure 3 as SPG_{tson}, SPG_{kan}, SPG_{chag}, errors in measuring the phases of cardiac cycles are estimated by the time coordinates of the informative points.

Characteristic points of pulse waves (extreme and inflections) were identified by numerical methods on a curve with a length equal to one cardiocycle. The geometrical arrangement of these points on the pulse curve made it possible to obtain an objective idea of its shape.

The phases of the cardiac cycle (*AC*, *IC*, *Em*, *Er*, *P*, *IR*, *Fr*, *Dy*, *Sa*), indicated in the upper part of Figure 3, were determined by the physiological curves obtained by the standard polycardiographic method including: electrocardiogram (*ECG*), velocity
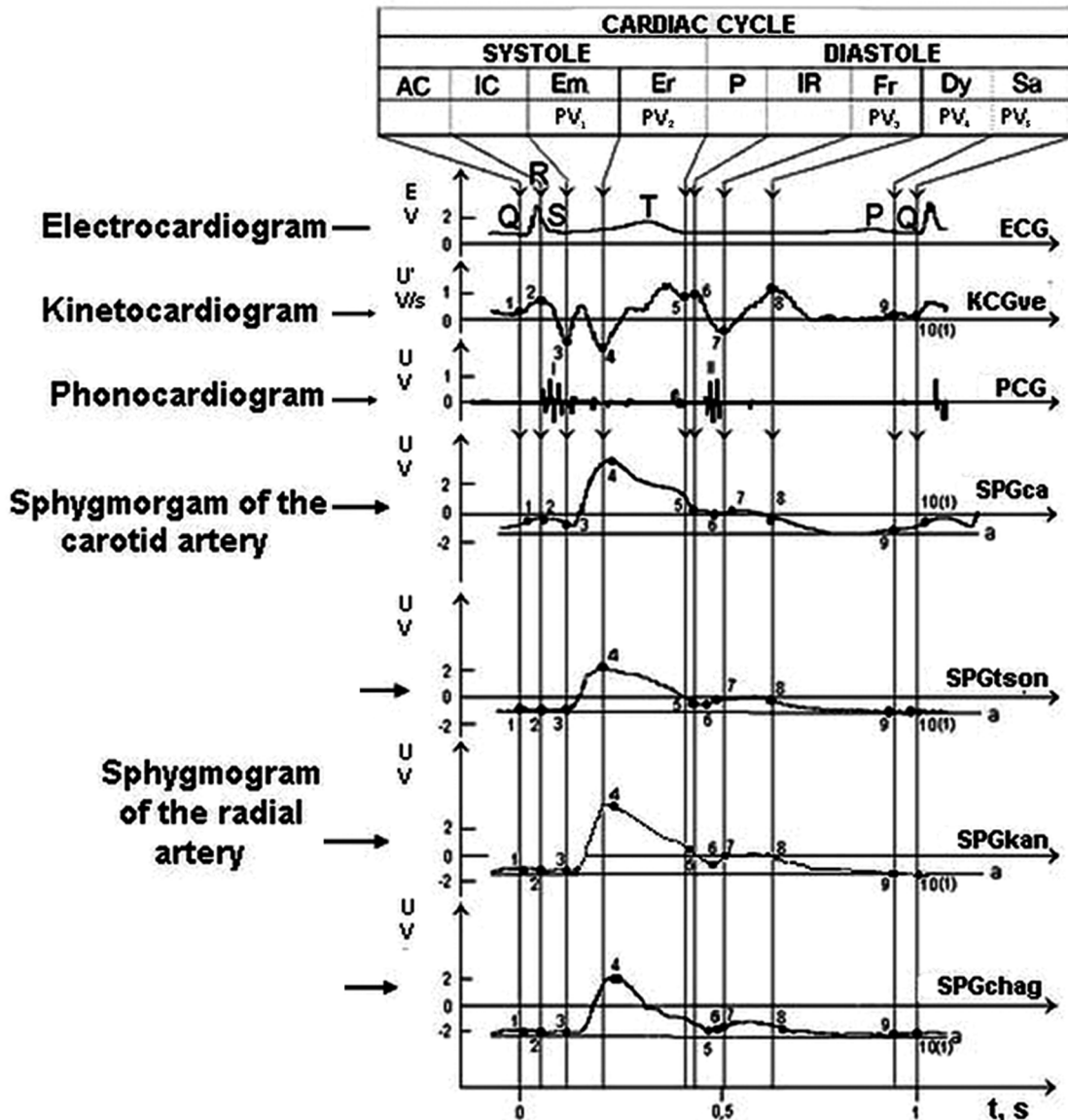

Fig. 3 — Comparison of the cardiac cycle phases by radial artery sphygmograms measured at three traditional palpation points — Tson, Kan, Chag

kinetocardiogram (KCG_{ve}), phonocardiogram (*PCG*), and carotid artery sphygmogram (SPG_{ca}). The vertical lines in Figure 3 indicate the beginning and the end of these cardiac cycle phases and are used to detect the characteristic informative points on the pulse curves recorded at three traditional palpation points (SPG_{tson}, SPG_{kan}, SPG_{chag}) of the radial artery[10]. Therefore, the location of the characteristic points on the *SPG* of the radial artery and the corresponding time intervals were compared both with each other and with the corresponding phases obtained using classical *ECG*, KCG_{ve} and *PCG* curves[11].

The mutual correlation of the phase characteristics of the radial artery sphygmograms was investigated at three palpation points using a *two-sample Student's t–test* for the case when both variances σ^2 are unknown and, moreover, their equality is not necessary[12].

The assessment of the statistical correspondence of the phase intervals of the cardiac cycle according to SPG_{ra} is given in Tables 1, 2, 3.

On comparing the absolute values of the t–criterion given in Table 1, 2, 3 with the distribution density function, where instead of an integer number of degrees of freedom there is an arbitrary positive number *Q*, it should be noted that in all the cases the *Student's criterion* does not exceed the threshold value. This indicates that with an established error probability (reliability) equal to 5%, it can be stated that there are no differences in the correctness of measurements of the cardiac cycle phases using sphygmograms of the radial artery SPH_{tson}, SPG_{kan}, SPG_{chag}.

This means that the data on the systolic and diastolic phases of the cardiac cycle obtained by using sphygmograms of the radial arteries are statistically homogeneous, do not depend on the point of measurement and therefore do not contradict the methods of phase measurements used in modern scientific medicine.

It is important for clinical practice to quantify the shape of a pulse wave by a number of indicators, which is relevant for working on the objectifying pulse diagnostics of Tibetan medicine. When palpating pulse, a Tibetan doctor focuses on its amplitude and time characteristics. The time parameters mainly serve to establish the mutual correspondence of the pulses; the amplitude characteristics are used to differentiate pulses according to nosological features.

From the point of view of diagnostics, signal elements that are most stable in time throughout the recording are most convenient for examining the statistical and correlation characteristics of pulse signals.

The mutual coefficients of spatial correlation (*CCF* — cross correlation function) ρ between the first pulse wave in the length of the recording and the rest pulse waves have been calculated[13].

The most probable range of the cross-correlation function (*CCF*) changes for a practically healthy person within one length of recording at three points *Tson*, *Kan*, *Chag* is $\rho = (0.95 \div 0.98)$ with an average value of $\rho = (0.97 \pm 0.015)$. This means that the shape of a single pulse wave follows, with high accuracy, the shape of adjacent pulse waves within the same recorded length.

For example, in case of atrial fibrillation, the *CCF* range was $\rho = (0.683–0.998)$, with an average value of $\rho = 0.918$. The length of the recording in the experiment was 500 pulse beats.

Thus, in healthy people, the comparison between the shapes of radial artery sphygmograms calculated by the method of correlation analysis, on the one hand, and by statistical methods, on the other hand, showed a high degree of similarity between the shapes of the contours of the radial artery sphygmograms.

With regard to sick people, the shape of the contours of pulse waves recorded at the palpation

Table 1 — Calculation of t–Student's criterion for the phase intervals of the cardiac cycle according to SPG_{ra} at points Tson and Kan									
Phases of the cardiac cycle	AC	IC	Em	Er	P	IR	Fr	Dy	Sa
t	0,118	0,886	1,072	0,685	0,824	1,604	0,220	0,046	1,541
Q	8	6	6	9	6	11	9	11	10
Table 2 — The same for SPG_{ra} at points Tson and Chag									
Phases of the cardiac cycle	AC	IC	Em	Er	P	IR	Fr	Dy	Sa
t	0,762	1,195	1,098	0,085	0,463	1,183	0,207	0,352	1,774
Q	11	11	11	8	6	11	10	11	9
Table 3 — The same for SPG_{ra} at points Kan and Chag									
Phases of the cardiac cycle	AC	IC	Em	Er	P	IR	Fr	Dy	Sa
t	0,793	2,433	0,122	0,765	0,821	0,502	0,000	0,272	0,356
Q	10	8	11	10	11	10	11	11	7

points that corresponded to diseased organs differed from the shape of the contours of pulse waves recorded at palpation points that corresponded to healthy organs.

Results

The total number of patients examined with the help of the *CPDS* in the medical institutions of Ulan-Ude (the Republic of Buryatia, Russia) is over 7000 people.

The medical tests have shown that the *Computer Pulse Diagnostic System* (*CPDS*) is designed for simultaneous instant assessment of the functional state of twelve internal organs (the heart, small intestine, spleen, stomach, left kidney, genitals, lungs, large intestine, liver, gallbladder, right kidney, urinary bladder) both in terms of modern scientific medicine and in terms of Tibetan medical system, which is due to the fact that modern scientific medicine has a large number of standard methods of functional diagnostics and biochemical analyzes; therefore, it provides unbiased diagnostic data accepted by the medical community.

The *CPDS* testing by methods of modern scientific medicine is carried out regularly. The medical bases for testing the *CPDS* are the *Republican Clinical Hospital for War Veterans* and the *Center for Oriental Medicine of the Ministry of Health of the Republic of Buryatia* (*Ulan-Ude*).

The operation of the *CPDS* is based on the analysis of pulse signals, taken by highly sensitive sensors from six traditional points of a patient's radial arteries[14], using specially developed mathematical methods that guarantee the accuracy and efficiency of diagnostic assessments[15-18].

Objective diagnostic results obtained by the *CPDS* have been confirmed by clinical tests in the medical institutions. During one of the series of tests, 187 patients were examined using the *CPDS*. Since those were patients of the hospital, their diagnoses were known and had been confirmed by the standard methods of functional diagnostics of modern scientific medicine (*ECG, UltraSound, CT, ECG Holter monitoring, ABPM, ECHOKG, FGDS, spirography*, etc.), including clinical and biochemical laboratory tests. The *CPDS* data coincided with the results of the examination by the methods of modern scientific medicine by 85%[19].

Thus, the *Computer Pulse Diagnosis System* (*CPDS*) meets the requirements of modern medicine for devices that carry out express diagnostics both in hospitals and clinics to objectify functional indicators at the stage of primary diagnosis, to conduct an instant assessment of the effectiveness of treatment, as well as to be used in health surveys, especially in remote places[20].

Assessment of the state of health by the Expert Diagnostic System (EDS)

To test the diagnostic capabilities of the *CPDS*, both medical reports by doctors (specialists in pulse diagnostics of Tibetan medicine), and expert assessments of the computer programs for inspection and questioning were used.

Diagnostics correlates with the constitutional type of a person; therefore the concept of the norm is not absolute. Any changes in the functional state of an individual are essentially determined by the psycho-physiological type. The types of people are determined depending on the dominant *nyespa* and its functions in the body. The classical treatise «*rGyud bZhi*»[5] identifies seven psycho-physiological types of people: 1) people of *rLung*; 2) people of *mKhrispa*; 3) people of *Badkan*; 4) people of *rLung–mKhrispa*; 5) people of *Badkan–rLung*; 6) people of *Badkan–mKhrispa*; 7) the type of people that combines three *nyespas*[5,6,21].

For a Tibetan doctor, the psycho-physiological type has always been a good indicator of the homeostatic status of a patient's organism and of its adaptive capacity. There are seven types of homeostasis because the normal state of the body correlates precisely with the psycho-physiological type of a person; therefore, for each type, its own norm is determined. For example, the norm for *rLung* people is different from that for *Badkan* people, and so on. Information about the psycho-physiological types of people makes it possible to predict probable disorders, the required treatment, the level of adaptability to the environment, the inclination for a particular kind of activity, working capacity, fatigue, psychological and emotional characteristics, etc.

Assessment of the psycho-physiological type of a person permits avoiding mistakes in diagnosing *nyespa* disorders, when congenital signs inherent in a certain psycho-physiological type of a person can be mistaken for an imbalance of health. Correct diet and behavior, correlated with the psycho-physiological type, is of great importance.

For a quantitative assessment of the activity of the psycho-physiological systems (*rLung, mKhrispa, Badkan*), a computer diagnostic system has been developed. This software comprises a number of

computer programs. Two basic methods of Tibetan diagnostics — inspection and questioning — are used in this system[5,6,21]. This diagnostic system includes a number of tests — two of these determine, in an automatic mode, the correlation of three *nyespas* in the human body.

The first test determines the constitution, or the predominant psycho-physiological type of a person — this is basically a psychological test. The second test identifies the symptoms of *nyespa* disorders, *i.e.,* the *nyespa* that is mostly responsible for a disease or a dysfunction.

After the patients go through these two tests, the Tibetan doctors (*Tib. emchi*) palpate their pulse. After the *EDS* tests and pulse palpation by pulse diagnostics specialists, the state of the pulses is examined by the *CPDS*.

The use of these two tests, one after the other, shows a high degree of correlation between the results of these two tests (more than 70%) and thus confirms the feasibility of using the tests to assess the constitutional type of a person. Some deviations in the results of the tests can be explained by subjective factors like: distraction, poor night sleep, hurry, etc.

The second test, aimed at identifying the *nyespa* responsible for the disease, includes traditional questions that are commonly used by a Tibetan doctor when questioning a patient. These traditional questions have been formalized in the form of a computer test. The validity of the test has been confirmed by the *emchi* doctors, *i.e.,* experts in Tibetan medicine.

Since the number of symptoms can be large, the test includes the main symptoms according to the basic treatise of Tibetan medicine «*rGyud bZhi*»[5]. There are 76 symptoms in the test — 31 symptoms are caused by disorders in the *rLung* system; 21 symptoms are related to the *mKhrispa* system and 24 symptoms are the results of the *Badkan* system disorder.

In the first test, the psychological characteristics of the *nyespa*, in the second test, the symptoms of a disorder caused by an imbalance of any *nyespa* are assessed on a three-point scale, depending on their severity. If a *nyespa* sign or a symptom is highly pronounced, it is assigned 2 points. If the *nyespa* sign or a symptom is not very pronounced, it is assigned 1 point. If these are absent, zero is given. Finally, in both cases, the test programs show colored diagrams on the computer display that demonstrate the correlation of the *nyespa* in the organism of the patient.

The coincidence of the diagnoses obtained with the help of the *CPDS*, the diagnoses obtained by the *EDS* tests and those of the emchi–doctors (experts in Tibetan pulse palpation) is over 70%.

Integration of the CPDS and the EDS into the Integral Computer Diagnostic System (ICDS)

The basic goal of the research is the construction of the *Integral Computer Diagnostic System* (*ICDS*) that is currently being developed. The *ICDS* is going to integrate the *Computer Pulse Diagnostic System* (*CPDS*) and the *Expert Diagnostic System* (*EDS*).

Figure 4 shows the block diagram of a phased scientific and methodological preparation (levels 1-6) and instrumental implementation (levels 7-11) of the diagnostics methods. This scheme shows the fundamental problems of diagnostics of Tibetan medicine, based on its theoretical basis (level 1), which is the foundation for all the diagnostic methods.

The scheme in Figure 4 is the result of the research that leads to the conclusion that pulse diagnostics is fundamentally inseparable from the system of Tibetan medicine. In order to advance work on objectifying and automating pulse diagnostics, it is essential to study the entire system of Tibetan medicine — its philosophy, its theory, its language, the methods of examining patients, as well as the methods of medicinal and non-medicinal therapy. Only in the context of the above components, it is possible to comprehend and objectify the method of pulse diagnostics.

The diagram of pulse diagnostics implementation is shown in the right part of Figure 4 (levels 2–11). The stage of scientific and methodological preparation (levels 2–6) includes the analysis of the texts on Tibetan medicine and the study of the semantics of the terms.

As a result of the research, the physiological meaning of pulsations and its physical basis (level 3) have been clarified. Taking into account the physical and the physiological meanings of pulsations, the choice of a mathematical model of blood flow in high fluidity mode (level 4) and of a pulse wave mathematical model (level 4) for assessing the pumping function of the heart (level 4) has been substantiated. Further, on the basis of the pulsation research (level 5), a method of pulse measuring (level 6) has been developed and a directory of pulse characteristics (level 6) that includes 108 nomenclature characters has been compiled. Based on
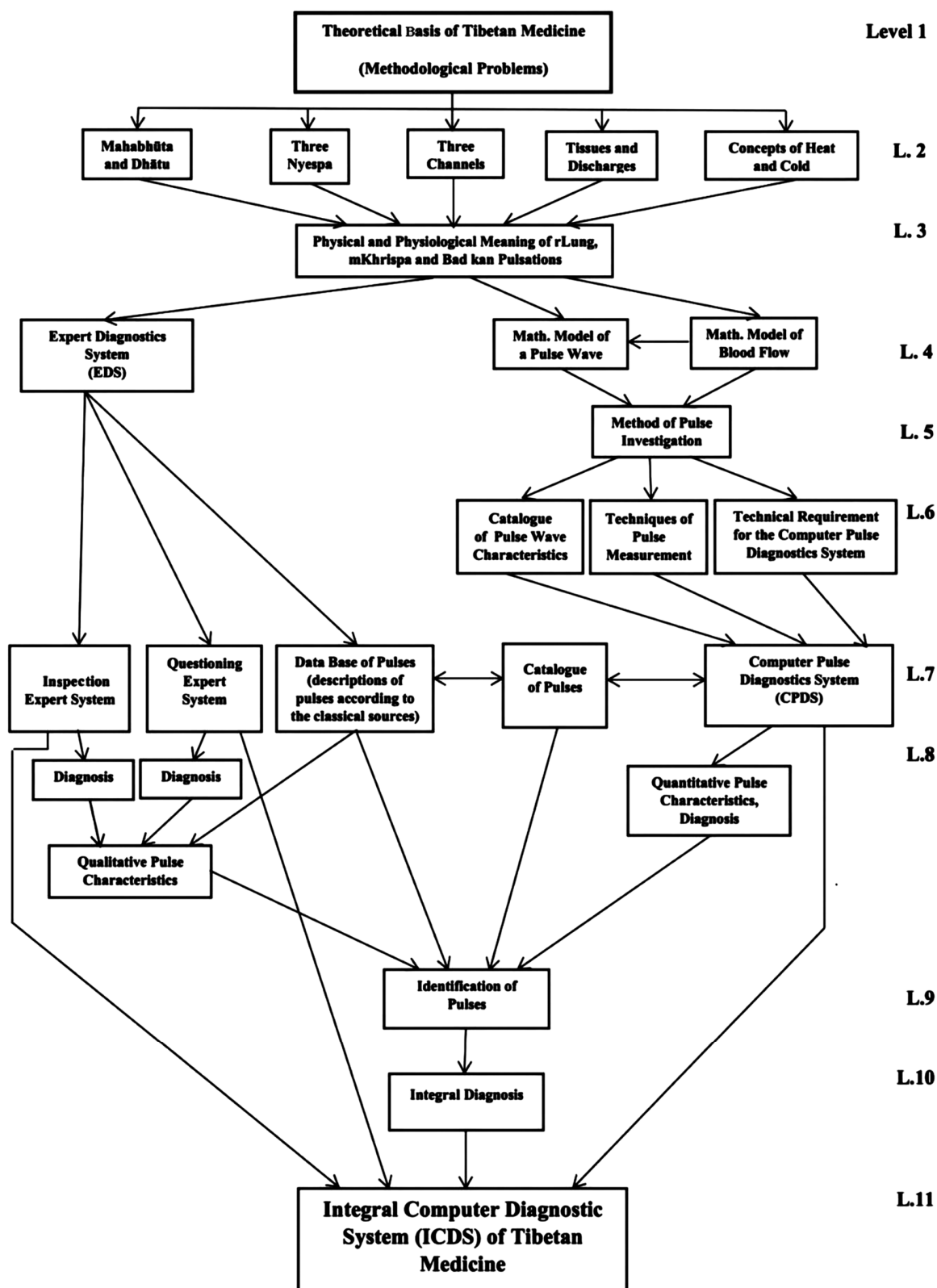
Fig. 4 — The scheme of diagnostics of Tibetan Medicine in the Integral Computer Diagnostic System

the results of the text analysis, a technical assignment (level 6) has been drawn up for the construction of the *Computer Pulse Diagnostic System* (level 7) and the *Expert Diagnostic System* (level 4 on the left side of Fig. 4).

The instrumental implementation of an integral way of using the palpation method as well as the questioning and the inspection methods of diagnostics is shown in Figure 4 (levels 7-11). The main feature of this technique is the ability to quantitatively assess the characteristics of pulse waves, to differentiate pulsograms according to these characteristics and to create the catalog of pulses (level 7). The catalogue of pulses is the basic block that is going to connect the *Computer Pulse Diagnostic System* (*CPDS* — level 7) that actualizes the diagnostic method of palpation with the *Expert Diagnostic System* (*EDS* — level 7) that actualizes the diagnostic methods of inspection and questioning.

The first variant of the diagnosis is made with the help of the *CPDS* according to the quantitative characteristics of pulse waves. The second variant of the diagnosis is made with the help of the *EDS* by inspection and preliminary questioning. The third variant is made with the help of the *EDS* by questioning (two tests — the first test is the psychological one for determining the dominant *nyespa* in the body; the second test is designed for revealing the symptoms of disorders in the organism). In the *Integral Computer Diagnostics System* (*ICDS*), three variants of diagnosis are going to be compared with each other, analyzed and, if they coincide, the definitive diagnosis, methods and means of treatment will be reported to the doctor. If the diagnoses do not coincide or one of them differs, the diagnostics procedure will be revised and repeated.

For several years, work on compiling the catalog of pulses has been carried out in a constant group of 30 volunteers four times a year according to the seasons of the Tibetan calendar. The group was selected so that the subjects of different psycho-physiological types should be included. According to the data obtained, the diagnoses made by the *emchi*–doctors and the diagnoses made with the help of *CPDS* coincide on average in 75% of cases.

An extensive database has been accumulated for compiling a directory of pulses for two main types of diseases: «hot» and «cold» diseases. This directory is going to become the basis for expanded and differentiated catalog of pulses for identifying specific diseases in the nosology of both Tibetan and modern scientific medical systems.

Work is in progress on the differentiated and expanded catalog of pulses. The pulse catalog and the pulse wave pattern recognition program designed to compare measured and reference pulses will make the basis for combining the diagnostic results by three diagnostic methods, which will lead to the creation of the *Integral Computer Diagnostic System* (*ICDS*) designed to diagnose diseases and to provide recommendations for correcting patients' health in accordance with the traditions of Tibetan medicine.

Discussion

The studies for objectification and automation of pulse diagnostics by developing the *Computer Pulse Diagnostic System*, as well as the *Expert Diagnostic System*, have shown the possibility of using the methods of Tibetan diagnostics (inspection, palpation, questioning) in practical medicine by information technologies. Statistical models of normal and pathological pulses (pulses of «hot» and «cold» diseases) have been developed on the basis of assessments of the pulse palpation results obtained by the *emchi*–doctors and of the diagnostic characteristics of pulse waves determined by mathematical methods. A directory of patterns of «hot» and «cold» pulses has been compiled. The *Computer Pulse Diagnostics System* (*CPDS*), which is the technical basis of the *Integral Computer Diagnostic System* (*ICDS*), meets the requirements of modern medicine for devices that perform instant diagnostics of patients' functional state. Medical tests have shown that the *Computer Pulse Diagnostics System* (*CPDS*) is designed to simultaneously assess the functional state of human internal organs both within in terms of modern scientific medicine and in terms of the Tibetan medical system. Objective diagnostic results obtained with the help of the *CPDS* coincided by 85% with the results of examining the patients by methods of modern scientific medicine. The coincidence of the diagnoses obtained using the *CPDS*, the diagnoses obtained using the tests of the *Expert Diagnostic System* (*EDS*), and the conclusions of the experts in Tibetan pulse palpation is over 70%.

Conclusion

The instrumental approach to the Tibetan diagnostic methods has shown that they are fundamentally inseparable from the system of Tibetan

medicine. To solve the problem of objectifying and automating pulse diagnostics and the other Tibetan diagnostic methods, it is essential to study the entire system of Tibetan medicine — its philosophy, its theory, its language.

The work at the *Computer Diagnostic Systems* has shown that the traditional Tibetan medicine has a rational basis to be assessed by physical and mathematical methods. Traditional medical knowledge provides a source of complimentary methods that should be studied by modern science and can be used in clinical settings.

Acknowledgement

Conflict of Interests
The authors declare no conflict of interests.

Authors' Contributions
BV conceived the idea and guided the development and construction of the *CPDS*. BV developed the methods of pulse waves processing and the detection of the diagnostic characteristics of pulse waves. PN was responsible for the development of the tests of the *EDS*. Both the authors verified the diagnostic methods described in the paper, discussed the results and contributed to the final manuscript.

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