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Regression analysis of radial artery pulse palpation as a potential tool for traditional Chinese medicine training education

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Summary Pulse palpation was an important part of the traditional Chinese medicine (TCM) vascular examination. It is challenging for new physicians to learn to differentiate between palpations of various pulse types, due to limited comparative learning time with established masters, and so normally it takes many years to master the art. The purpose of this study was to introduce an offline TCM skill evaluation and comparison system that makes available learning of palpation without the master's presence. We record patient's radial artery pulse using an existing pressure-based pulse acquisition system, then annotate it with teachers' evaluation when palpating the same patient, assigned as likelihood of it being each pulse type, e.g. wiry, slippery, hesitant. These training data were separated into per-doctor and per-skill databases for evaluation and comparison purposes, using the following novel procedure: each database was used as training data to a panel of time-series data-mining algorithms, driven by two validation tests, with the created training models evaluated in mean-squared-error. Each validation of the panel and training data yielded an array of error terms, and we chose one to quantitatively evaluate palpation techniques, giving way to compute self consistency and mutual-similarity across different practitioners and techniques. Our experiment of two practitioners and 396 per-processing samples yielded the following: one of the physicians has much higher value of

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self-consistency for all tested pulse types. Also, the two physicians have high similarity in how they palpate the slipper pulse (P) type, but very dissimilar for hesitant (H) type. This system of skill comparisons may be more broadly applied in places where supervised learning algorithms can detect and use meaningful features in the data; we chose a panel of algorithms previously shown to be effective for many time-series types, but specialized algorithms may be added to improve feature-specific aspect of evaluation.

Introduction

Within traditional Chinese medicine (TCM), radial artery pulse diagnosis was a large aspect of the practice and was widely given as the alternative (and oftentimes, the main) medicine. The TCM pulse palpation was regarded as a difficult learning task and often takes student years to build the intuition.[1] Each school of TCM can be quite varied and teaches their own variation of palpation, and even develop within new and unique styles of pulse reading. Similar to any art traditions these practice improve or become specialized, e.g. to fit local population characteristics (e.g. diet, body, and belief).

Presently a new student learns pulse palpation amongst masters where the palpation knowledge had passed down generations, and improved over time. To master palpation, in addition to text book description of different pulse types, there require frequent interaction palpating the patients with experienced teachers present, this places a limitation on learning opportunities and a new students often take years to develop diagnostic alignment with teacher.[1] Also, the current approach of learning pulse palpation placed a heavy burden on the instructors who often were liable for the quality and alignment of their students' practice. The teacher scarcity and the demand of their time bottleneck the number of students who may follow and the rate of their skill maturation. Modern teaching technologies such as distant learning were also not possible.

Many attempts have appeared over the years to modernize aspects of TCM. Project such as Unified Traditional Chinese Medical Language System (UTCML) in 2001 tried to build a reusable ontology for TCM, their goal was standardization of terminology and knowledge acquisition.[2] Project like this encode knowledge with techniques such as written text and recorded media. What is still missing were ways of recording and effectively teach/compare sensory experiential knowledge, e.g. knowledge that resist encoding by words, pictures, sound, or videos. Radial pulse palpation was a medical art solely based on the sense of touch and would be a good testing ground.

Pulse palpation has many dimensions to its measurements, such were the waveform depth, rate of recurrent features, strength and magnitude of waves, their shapes, rhythm, etc.[3] In this paper we pick three subtypes of pulse waves — wiry (W-pulse), slippery (S-pulse), and hesitant (H-pulse) — for their affinity toward mutual morphological differentiation, and for their known difficulty to new practitioners. Typical textual descriptions of these pulse subtypes in Ref. 4 were as follows:

- Wiry pulse (W-pulse) was ''a pulse that feels straight and long, like a musical instrument string. This pulse type was often found in normal persons or patients whose liver and gallbladder were in disorder or have severe pains.''
- Slippery pulse (P-pulse) was ''like beads rolling on a plate, was a fluent pulse and often present in normal persons, pregnant women, and patients who were phlegm-damp or food stagnation.''
- Hesitant pulse (H-pulse) was ''like a knife scrapes across bamboo, was a choppy pulse, and denotes that the blood circulation was slow as a result of blood deficiency or qi and blood stagnation.''

In the remaining of the paper we propose a novel method of identifying and comparing palpation skills that were data-captured for each particular practitioner, for different skills of reading the pulse aforementioned. The quantitative comparison of skills may allow modes of learning such as distance learning and offline learning that were previously difficult to imagine for teaching palpation. In next sections we detail the data capture of radial artery pulses, process them into comparable signatures, then use them to compute between-physician similarity and per-physician consistency. We then discuss how these may be applied toward off-line learning of sensory-based experiential skills.

Methods

Data collection

Pulse measurement

Pulse may be taken at the radial artery (wrist) site using various technologies. Not all techniques acquire pulses from this site. Current trend of computerized TCM pulse diagnostics relies on one or more of following for data collection methods: (1) simple single-pressure setting pulse reader,[5] (2) mechanical arm sensor,[6] (3) finger-tip pulse sensor.[7] The pulse data tend to be more reliable at the radial artery site and comparable to TCM methods. In this paper we used only the pressure-based acquisition of pulse data from radial site.

Radial artery pulse diagnosis was a medical procedure where the physician places finger tips over the wrist radial site and gently apply varied pressure — similar to how a sphygmomanometer builds pressure initially and then release pressure in steps — the practitioners gradually and intermittently apply pressure while simultaneously reading the pulse response from the patient's wrist, this continues until the greatest pulse response was found. Pulse reading may then be conducted here, without further changes to the pressure.

Tonometry (pressure) based devices have been constructed to measure pulse in Refs. 8, 9, including early day