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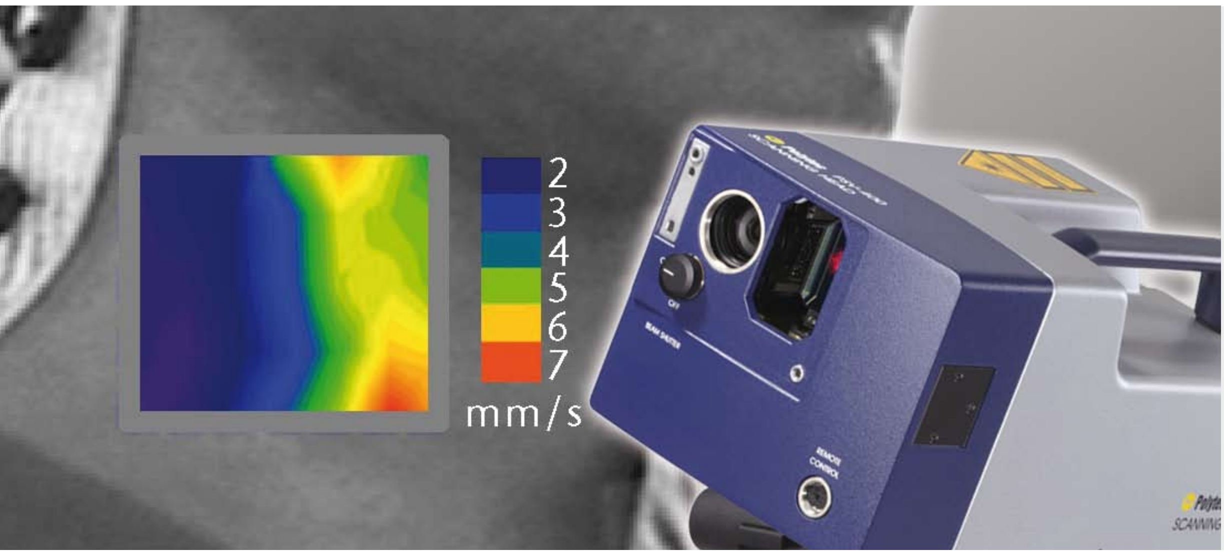
Measuring and Scanning Physiological Signals



Polytec Technical Papers

Measuring Physiology and Biometrics from a Distance Using Laser Doppler Vibrometry

Laser-Doppler vibrometry (LDV) is widely used in industrial and engineering applications but its use for measuring system-level physiology is fairly recent. Although this application is novel, it is based on a conventional and familiar premise in clinical medicine that the majority of physiological activities have mechanical components, and the energy is transmitted, however minutely, to the skin. Accordingly, a large variety of internal sounds, pulses and vibrations can be detected simply by directing the laser beam at the body.

This principle underlies important aspects of a typical medical clinic exam with its emphasis on heart and lung sounds and palpated activities. As a consequence, there is a rich clinical and scientific literature database describing the basic form and physiological significance of these signals to guide their measurement and interpretation. Multiple investigators in the Washington University School of Medicine and School of Engineering have contributed to the development of a dedicated instrument that supports acquisition of LDV data on a largely autonomous basis, with targeting, tracking and focusing of the instrument controlled using computer vision methods. Data are analyzed in near real time.

Advanced measures are supported in multiple response systems, especially cardiorespiratory and muscle activities. Several forms of cardiovascular signals can be assessed, including

- Gross ballistocardiac movements
- More local signals (particularly over the chest) associated with heart wall and torsional movements during the cardiac cycle
- Focal pressure-related signals from specific blood vessels.

Particular emphasis has been on the pulse signal recorded from neck sites (Fig. 1) overlying the carotid artery. These features support clinically-relevant assessment of cardiac performance and arterial dynamics, as well as acute effects associated with stress, emotion and exercise. In Fig. 2, patterns of muscle activity over the face are shown as measured using a Polytec Scanning Vibrometer. The red areas indicate increased vibration amplitude during contraction of specific muscles (within band of 16 to 32 Hz). The signal arises from lateral expansion of the muscles during contraction, which is by nature a vibrational process and can be measured from muscles throughout the body. These signals are being used to study the facial signs of emotion, stress and fatigue, as well as clinical disorders such as facial paralysis. In addition, the LDV signals appear to harbor a considerable amount of individuality, providing a possible basis for biometric recognition.

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Figure 1: Types of physiological signals that can be recorded using a Polytec vibrometer.

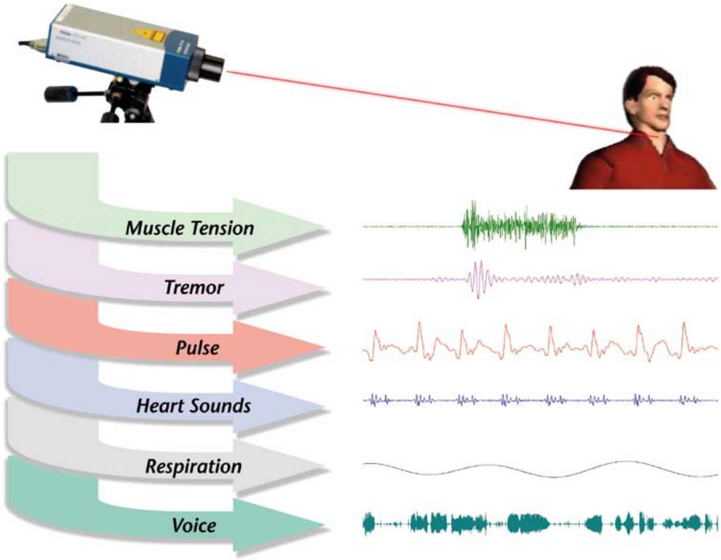
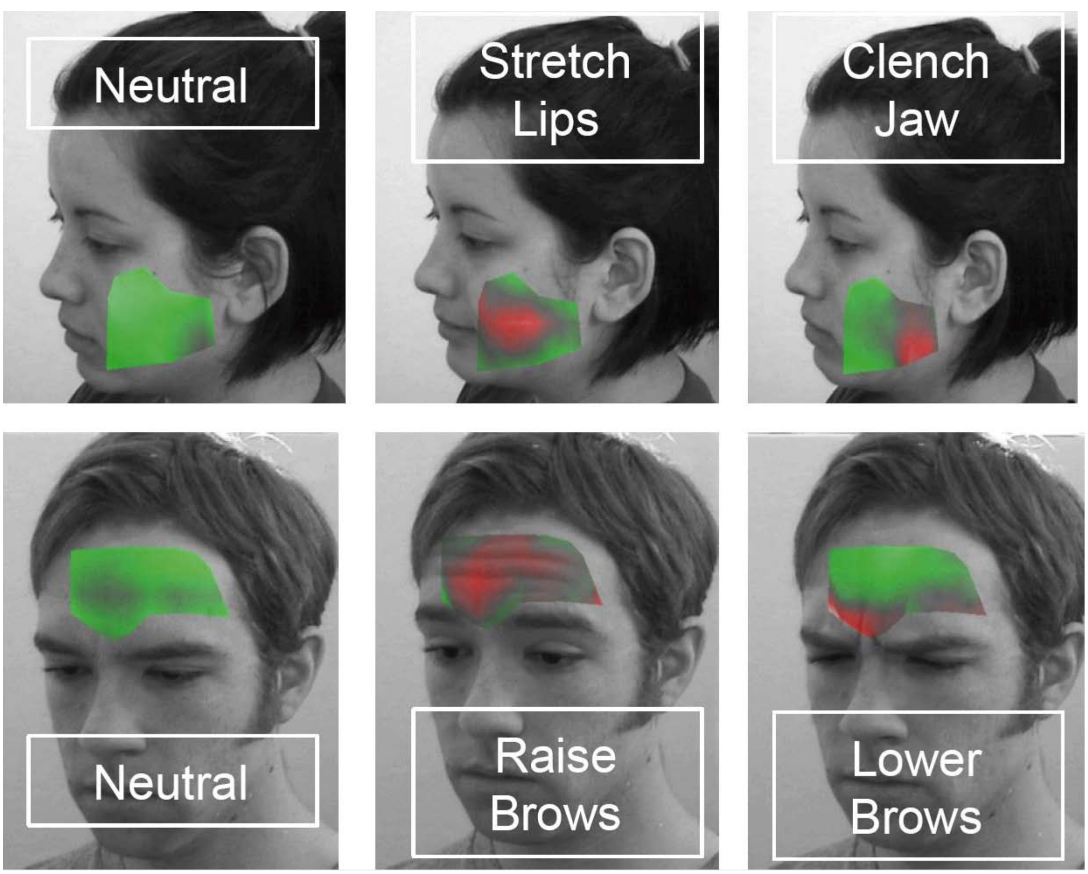


Fig. 2: Facial patterns of muscle activity measured using a Polytec scanning vibrometer.



Author • Contact

John W. Rohrbaugh, PhD, Washington University School of Medicine, St. Louis, MO 63130

jwrohrba@artsci.wustl.edu

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