Wearable Accelerometric Motion Analysis System ("WAMAS")

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Since 1989, the VA Palo Alto Rehabilitation R&D Center has been developing a Wearable Accelerometric Motion Analysis System with the goals of identifying patterns of human body movement that accompany loss of balance before a fall occurs, warning of pre-fall behavior, and if necessary, signaling that the wearer has fallen. As an adjunct to physical or occupational therapy, the WAMAS can act as a surrogate therapist, monitoring a patient's performance and providing cues as needed to encourage compliance with a course of therapy. We have identified a large number of medical and non-medical applications for WAMAS technology (see table below). The WAMAS occupies a niche in the spectrum of tools for diagnosis and therapy of movement disorders midway between qualitative estimation, and expensive laboratory-based gait analysis available only at a few locations. Analytical methods for WAMAS data differ from both conventional gait labs and "actimeters"; the WAMAS uses pattern recognition algorithms to detect clinically significant events, treating "body language" in much the same way as computer speech recognition.

WAMAS hardware is designed to be easily upgraded as new technology becomes viable, without invalidating past data records or processing programs. In particular, we anticipate converting sensor connections from wired to wireless, both in stand-alone form and as part of a telemedicine system. We have added output capability for audible, visual or tactile feedback to the WAMAS wearer, to help overcome mobility disorders such as Parkinson's Disease, and to encourage compliance with prescribed therapeutic exercise by automatic activation of voice instructions and cues.

Another unique feature of the WAMAS project is the library of motion data recorded in laboratory and clinical settings from more than 240 subjects of a broad range of ages and movement capabilities; this library can be used to establish norms for comparison with new data and to test new recognition algorithms, without the need to conduct more clinical trials.

The VA has assigned management of intellectual property to Stanford's Office of Technology Licensing (docket numbers S00-213 to -215) <http://otl.stanford.edu/>. Stanford's Biodesign Network is cooperating in the technology transfer effort <http://bdn.stanford.edu/>. Opportunities for collaboration with industrial partners include nonexclusive licensing, multi-partner arrangements with manufacturers and distributors, and Cooperative R&D Agreements to continue VA research (for the latter, see http://www.vard.org). For details on the use of WAMAS for mobility and balance analysis, see reports and presentations on http://guide.stanford.edu/People/sabelman/sabelman.html

APPLICATIONS		
Global category	**Specific applications**	**Characteristics & examples**
Diagnostic applications -	**Balance & posture assessment**	record movement for post-session assessment of performance
	Activities of daily living & dynamic motion tasks	functional & risk assessment
Therapeutic applications -		real-time outputs to enhance performance and/or inhibit non-optimal or injury-prone motion patterns.
	Gait assessment & therapy	Parkinson's Disease, postoperative hip arthroplasty
	Prevention of falls	reminder of unsafe motion patterns & alarm if a fall does occur
		component of active device for preventing hip fracture
	Pressure relief monitoring to prevent skin breakdown	spinal cord injured & frail bed-ridden patients
	Sensory loss compensation	diabetic or idiopathic neuropathy
Telemedicine -	**Post-surgical in-home monitoring**	computer-aided data interpretation is key contribution to remote monitoring
	Chronic mobility disorders	independently-living impaired individuals
		institutionalized individuals
Occupational applications	**Reinjury prevention**	WAMAS warns user if the movement pattern that caused injury exceeds a pre-set number of repetitions.
	Movement training	Expert wears WAMAS to record his/her performance, which then becomes ideal or model for training novice workers.
	Movement tracking for safety & rescue	WAMAS is being tested as part of a system for locating firefighters inside smoke-filled buildings
Exercise & athletic applications –		WAMAS would be loaded with either an ideal model, or with individual's past best performance to be exceeded
	Prescribed therapeutic exercise.	compliance improved
	Self-selected exercise	walking, running, climbing, fitness training & movement exercises/postures such as martial arts, yoga & Tai Chi Chuan.
	Individual athletic training.	Pole vault, high diving, jumping, gymnastics, discus & javelin throwing, track and field, golf and tennis
	Multi-body (team) athletic training –	each player wears a WAMAS; base station compares individual movements with model of team interactions.
		synchronization of rowing stroke & oar swing of all rowers in crew racing.
		baseball practice of pitcher, runner & basemen; optimize timing of a throw to put the runner out.
		rider & horse in equitation competition.
		offensive and/or defensive soccer players.
Non-human movement applications –	advantage over imaging is no need for fixed, structured environment.	record machine movement to test whether standards are met
		test acceleration, slope stability & braking acceleration of a motorized wheelchair.