Movement Analysis Core Facility

Resources

The Core maintains the following laboratories contained in the 55,000 sq ft Biomechanics Research Building.

This includes:

1. Aquatic Therapy Lab, BRB 021
2. CAREN Virtual Reality Lab, BRB 027
3. Gait Lab, BRB 035
4. Bioinspired Robotics Lab, BRB 037
5. GRAIL Virtual Reality Lab, BRB 103
6. Main Gait Lab, BRB 116
7. Balance and Strength Lab, BRB 123
8. Brain Imaging Lab, BRB 129
9. Academic Lab, BRB 158

Aquatic Therapy Lab, BRB 021

This 246 ft^2 lab is dedicated to a HydroWorx 300 (HydroWorx, Middletown, PA, USA) treadmill. It allows subjects to sit, stand, walk or run in a self-contained underwater treadmill. This buoys the subjects providing better rehabilitation. The warm water therapy also provides added comfort.

CAREN Lab, BRB 027

This 1083 ft^2 lab will house a Computer Assisted Rehabilitation Environment (CAREN) (Motek ForceLink, Amsterdam, Netherlands). It is similar to the GRAIL Lab but is larger and has more features. It includes a 180-degree screen and front-mounted projectors. It uses ten Vero motion capture cameras (Vicon Motion Systems Ltd, Oxford, UK). The treadmill is a split-belt design with belts on the left and right sides of the treadmill. Each side can measure six-component ground reaction forces. This treadmill is supported on a motion base with six degrees of freedom. The environment is also controlled through Motek ForceLink's D-Flow software and has several options for third party device integration. It is temporarily housed in BRB 116.

Gait Lab, BRB 035

This 1335 ft^2 lab features five AMTI high-performance force platforms (AMTI Inc., Watertown, MA, USA) and a 12-camera Raptor 4s motion capture system (Motion Analysis Corp, Rohnert Park, CA, USA). The force plates are embedded in a modular 3x4 array with many potential configurations. Filler plates with mechanical properties similar to the real force plates are used to fill in spaces around the actual force plates. The array is in-line with double doors to BRB 027 so extended sprinting studies can be conducted. The force plates are part of AMTI's Optima High Performance line and feature composite tops that

increase the resonant frequency of the platforms. The Raptor 4s cameras operate at 4 MP resolution up to 200 Hz.

Insect Lab, BRB 037

This 158 ft^2 lab is used for insect biomechanics. The climate-controlled room is maintained at 90 °F, was designed with escape barriers, and has an adjoining preparation and storage space. Insect movement is recorded in a custom made containment area using one TS5 and two IL5 high-speed digital cameras (Fastec, San Diego, CA, USA). These cameras can be used to record HD color or monochrome images. The TS5 can capture 2560 x 1440 images at 359 fps. The IL5 can capture similar images but while connected to a computer. Both models can collect images over 1000 fps can be mounted on a tripod or used as a handheld.

GRAIL Lab, BRB 103

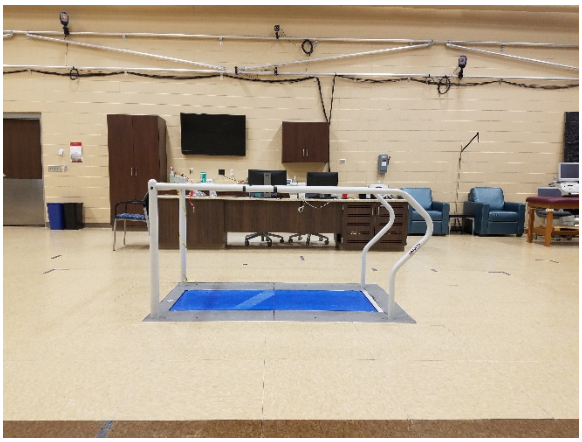
The VR Lab is a 1,462 ft^2 space primarily featuring a Gait Real-time Analysis Interactive Lab (GRAIL) (Motek ForceLink, Amsterdam, Netherlands). It is integrated with 14 high-speed Vero Series cameras, 1 Bonita high-speed high-definition camera (Vicon, Oxford, UK) and an instrumented treadmill (Bertec Corp., Columbus, OH, USA). The treadmill has a split-belt design with separate belts running side by side. Each side is instrumented to measure 6-component ground reaction forces. The virtual environment is created by a front projection system and displayed onto a 180-degree screen and floor. The four projectors, consisting of one Optoma TX774 with 4000 lumens brightness and 2500:1 contrast ratio, three Barco F50s with 5,000 lumens and 5300:1 contrast ratio, all controlled by dedicated computers. Virtual environments can be created in-house using Computer Aided Design (CAD) software or obtained from Motek ForceLink. These environments can also be displayed into an Occulus Rift (Occulus, Menlo Park, CA, USA). The system includes an A/D board and Phidget mechanical relay box (Phidgets Inc, Calgary, Canada). Both can be used to interface the GRAIL with other systems.

Portable equipment used primarily in this lab includes:

Humotech: Two actuator units and four different end effectors from Human Motion Technologies (Humotech, Pittsburgh, PA, USA) are available. The actuator units use MATLAB and SIMULINK (MathWorks, Natick, MA, USA) to control the end effectors. These effectors include an ankle prosthesis, ankle exoskeleton (2), hip exoskeleton and harness. The system can integrate data from our instrumented treadmills and wired EMG systems for use in the effector's control algorithms.

Main Gait Lab, BRB 116

This 2,535 ft^2 lab features a 3-D motion capture system with 14 high-speed Raptor cameras (Motion Analysis Corporation, Rohnert Park, CA, USA). It is integrated with 3 Gen5 and 5 Optima strain gage force platforms (AMTI, Watertown, MA, USA), and tandem-belt instrumented treadmill (AMTI, Watertown, MA, USA). Each of these is mounted into a concrete subfloor surrounded by a trench for cable management. It is also integrated with a dedicated, but portable, 16 sensor Avanti Trigno Delsys EMG system.

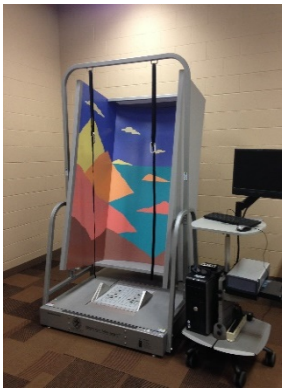


Portable equipment used primarily in this lab includes:

Stairway: Our four-step stairway includes three stairs with strain gage force platforms (Bertec, Columbus, OH, USA) and a top non-instrumented platform. Handrails on both sides are instrumented (Bertec, Columbus, OH, USA). It can be readily integrated with the Motion Analysis system with full coverage of the cameras. This allows four continuous steps during stair ascent and descent, three of which with complete kinetic and kinematic measurements. This system is mounted on adjustable casters that allow it to be moved and can be raised to fix it in place.

Instrumented Walkway: Our Zeno Walkway (ZenoMetrics LLC, Peekskill, NY, USA) is a 4 ft by 20 ft instrumented walkway that can measure the spatial and temporal and characteristics of walking without any on-body instrumentation. It can be synchronized with other equipment using TTL signals.

Balance and Strength Lab, BRB 123



The Balance and Strength Lab (548 ft^2) primarily features two independent systems. 1) A Balance Master (NeuroCom Intl., Clackamas, OR, USA) that provides an objective assessment of balance control and postural stability under dynamic test conditions through the use of computerized dynamic posturography. The unit provides assessment and retraining capabilities on a stable or dynamic support surface and in a stable or dynamic visual environment. A unique feature of this unit is that it includes separate clinical and research modules. The clinical modules provide standard testing protocols while the research module allows for the creation of custom protocols. 2) A System 4 (Biodex, Shirley, NY, USA) is a dynamometer that can measure strength and fatigue during a variety of exercises. It comes with multiple attachments for the dynamometers to accommodate exercises involving the limbs and torso. It also includes a chair with several positioning, rotation and inclination adjustments.

Brain Imaging Lab, BRB 129

This 178 ft^2 space houses equipment used for noise-sensitive brain imaging and features an airlock and concrete walls for noise cancellation. The ETG-4000 24 Channel Optical Topography System (Hitachi Medical Systems, Tokyo, Japan) is an FDA approved device that enables imaging of the cerebral cortex during sitting or standing using infrared technology. An electroencephalogram (EEG) from Electrical Geodesics Inc. (Eugene, OR, USA) measures the electrical activity in the brain. It uses a net of 130 electrodes wrapped around the scalp and face. The system is integrated with E-Prime software (Psychology Software Tools) and peripheral sensors including: EKG, oximeter, airflow sensors and polygraph. It installed on a wooden desk with casters for electrical isolation and portability. An NDI 3D Investigator motion capture system (Northern Digital Imaging, Ontario, Canada) uses Optotrak Smart Markers for improved tracking and labeling of the markers. The markers are active markers, using specific frequencies of light to improve accuracy. This system has allows simple motion to be tracked in small spaces. An InMotion 2.0 Shoulder Robot (Interactive Motion Technologies, Watertown, MA, USA) allows patients to use a motorized arm to complete tasks and games on a flat-screen display. The arm is actuated allowing force feedback to be communicated to the patient.

Teaching Lab, BRB 158

This 294 ft^2 lab features an 8 camera T160 motion capture system (Vicon Motion Systems, Oxford, UK). It is integrated with 4 OR6 strain gage force platform (AMTI, Watertown, MA). The space also contains an instrumented treadmill (Bertec Corp., Columbus, OH, USA). The treadmill has a split-belt design with

separate belts running side by side. Each side is instrumented to measure 6-component ground reaction forces. This space is used primarily for the education of undergraduate and graduate students.

Portable Equipment

The Biomechanics Research Building houses numerous equipment that is used in multiple labs and is not assigned to any particular space.

Metabolics: 1) A Parvo system (Parvo Medics, Sandy, UT, USA) is a metabolic cart used to measure intrapulmonary gas exchange analysis during stationary studies, such as running on a treadmill or pedaling on a stationary bicycle. It can provide an accurate measure of pulmonary gas exchange, i.e. VO2, VCO2, Ventilation, energy expenditure, etc. 2) Another metabolic system, Cosmed K5 (Cosmed USA Inc., Chicago, IL, USA) provides similar measurements to the Parvo. However it can provide a breath-by-breath analysis with greater detail. It is also more portable and can be used with non-stationary studies.

Ultrasound: 1) An imaging ultrasound (Telemed, Milan, Italy) can be used to image muscle activity in real-time during gait or other activities. It can also be synchronized with any of our motion capture systems.

Electromyography (EMG): Two Trigno EMG systems (Delsys Incorporated, Boston, MA, USA) together have 24 Trigno Avanti and 24 Trigno wireless sensors that can be freely paired with installed software on desktops, laptops and mobile devices. Each Avanti sensor includes one EMG channel and a full IMU for a total of 10 channels per sensor. Each base Trigno sensor includes one EMG channel and one tri-axial accelerometer. Data from these sensors can be recorded directly through Delsys EMGWorks software, with motion capture systems. Synchronization is allowed with an additional Delsys Trigger Module.

Eyetracking: 1) A Glasses 2 (Tobii, Stockholm, Sweden) head-mounted eye tracker that samples gaze data at 100 Hz. It simultaneously records video from a front-mounted camera and has interchangeable corrective lenses. It can both send and receive event signals. 2) The faceLAB 5 (Seeing Machines, Inc., Acton, MA, USA) records eye movement, head position and rotation, eyelid aperture, lip and eyebrow movement, and pupil size. The system integrates with EyeWorks™ (Eyetracking, Solana Beach, CA, USA) for additional eye-gaze analytics. 3) A second eye tracking system (RED250mobile, SensoMotoric Instruments, Teltow, Germany) provides less information but can be controlled through Matlab and C++, allowing for greater customization.

Inertial Motion Capture: 1) Two Awinda motion capture systems (XSENS, Enshede, Netherlands) allow joint angles to be recorded. They use markerless technology based on inertial measurement units to record movement. They can be used inside and outside the lab and be synchronized with other equipment. 2) Another Opal motion capture system (APDM, Portland, OR) can measure kinematics. It can also be synchronized with other systems using TTL signals.

Motion capture: A 6 camera OQUS motion capture system (Qualisys, Göteborg, Sweden) can be set up in one of the labs or taken to remote locations to track the kinematics of passive markers.