Biomechanics Gait Analysis Lab

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Overview

■ Background
  ➢ Client & Needs
  ➢ Previous Works by Others
  ➢ Patents

■ Project Description
  ➢ Objective
  ➢ Methods

■ Budget

■ Project Highlights
Background

■ Client
  ➢ Dr. John D. Enderle
  ➢ Program Director & Professor, Biomedical Engineering, University of Connecticut

■ Needs
  ➢ Update & Expansion of Gait Analysis Lab
    • Force Measurement System
    • Computer Program
Background

Previous Work Done by Others

- Foot Pressure Devices
  - Mats & Insoles
    - Dynamic weight transfer and local pressure concentrations (pressure & force)

WalkwayTM System
www.tekscan.com

F-Scan® System
www.tekscan.com
Background

Previous Work Done by Others

- Force Plates
  - Ground Reaction Forces
  - Vertical & Shear Forces
  - Center of Pressure

4060-NC Force Plate Series
www.bertec.com

4060 Force Plate
www.bertec.com
Background

- **Motion Systems**
  - Electromyography (w/ goniometer & accelerometer)
  - Video Motion Systems

- Measure joint angle and acceleration

Peak Motus  
www.vicon.com

Inline Electrical Goniometer  
www.noraxon.com

Inline Accelerometer  
www.noraxon.com
Background

Patent Search Results

- 6,997,882 6-DOF subject-monitoring device and method –Parker, et al. (methods & devices using accelerometer)
- 4,631,676 Computerized video gait and motion analysis system and method –Pugh; James W. (computerized video & motion system)
Project Objective

- Design and build gait analysis laboratory for UConn’s biomechanics course by December 2006.
  - Create a LabVIEW® software program to analyze:
    1. Digital data from the force measuring device
    2. Images from the video camera(s)
  - Design and fabricate a force measuring device that is:
    1. Portable
    2. Easy to set-up
    3. Cost-efficient
  - Utilize the National Instruments PXI – 1031 and BNC – 2100:
    1. Convert the analog data from the force measuring device to digital data the LabVIEW® program can read
    2. Image acquisition via S-video cable from video camera(s)
Methods

Overview

- Clinical Gait Model and Kinematic Data Analysis
  - Segmentally fixed coordinate system
  - Net joint reactions
- Force Measuring Device
  - Force Plates
  - Pressure Mats
  - Gait Mats
- Optoelectronic Systems
  - 2D versus 3D systems
The Clinical Gait Model is an algorithm that connects the data which is collected during the subject’s walking cycles to the information necessary for scientific analysis.

Kinematic Data Analysis
- 3 noncolinear reference points placed on body segment
- Plane formed for segmentally fixed coordinate system
- Markers should be referenced to anatomy
  - EX: for pelvis, place markers over R and L anterior-superior-iliac-spine (ASIS) and either R or L posterior-superior-iliac spine (PSIS)

Net joint reactions including joint forces and moments can be computed by combining ground reactions (forces, torque, pts of appl) with estimates of segment mass and mass moments of inertia.
Force Plates

■ A force plate is a device that measures the ground reaction forces exerted by a subject as they step on it during gait.
  - Top plate
  - Force transducers at each corner

■ 2 Types:
  1. *Piezoelectric*
     - Utilize quartz transducers that produce an electric charge when stressed
     - Require special charge amplifiers and low noise coaxial cables
     - No power supply needed
  2. *Strain Gauge*
     - Utilize strain gauges in specially machined aluminum transducer bodies referred to as load cells to measure stress
     - Require excitation of the strain gauge bridge circuit
     - Do not require special cabling or charge amplifiers

➢ Generally, the piezoelectric force plates are more sensitive and have a greater force range than the strain gauge force plates.
Pressure Mats

- A pressure mat is a quick and easy way of obtaining a plantar pressure picture of a subject as they walk on it during gait

- 2 Types of transducers in use for plantar measurement:
  1. **Capacitive**
     - 2 capacitor plates separated by a compressible rubber dielectric material
     - When pressure is applied, plates are pushed closer together, resulting in capacitance that is calibrated in units of pressure
  2. **Force Sensitive Resistor (FSR)**
     - 2 thin layers of flexible plastic with printed circuits on the inner surfaces, separated by a thin layer of double-sided adhesive
     - When pressure is applied, carbon on one surface contacts a metal pattern on the other surface, creating a resistive electrical circuit

- Since the transducers tend to be nonlinear, the precision of these systems relies on the ability to consistently calibrate them
Gait Mats

- A gait mat is a fairly new system that presents both temporal and spatial gait considerations.
- Consist of an array of switches embedded along the entire length of a long strip of walking surface, like a carpet.
  - Switches close under the feet, allowing the computer to compute the timing of each switch closure
  - Spatial parameters can be determined using the geometry of the mat
- Advantages
  - Removal of gait hindering attachments
  - Relatively low cost
  - Portability
- Disadvantages
  - Temporal resolution due to limitations in the scan rate
  - Spatial resolution due to the finite size of the switches
Optoelectronic Systems

- One or more video cameras can be used in a video system in order to track the bright markers that are placed on the subject along specific locations.
  - Passive Marker System – solid shapes with retroreflective tape
  - Active Marker System – infrared (IR) light-emitting diodes (LEDs)

- Three – Dimensional (3D) System
  - 2 or more video cameras
  - Computer software program calculates 3D coordinates for each marker using the 2D data obtained from the cameras.

- Two – Dimensional (2D) System
  - 1 video camera
  - Assume all of the motion is occurring on a single plane perpendicular to camera axis
  - Not recommended for use in gait analysis.
Budget

- Importance of project cost for a client
  - The price of the project compared to the market
  - Profitability
- What would the client or the company gain from this project?
  - Is it more efficient than the existing product?
  - How much is the client willing to spend?
Cost of the Project

- Our project is lower in cost compared to market prices
  - Components are already available and are required to use...
    - The digital cameras
    - National instrument PXI-1031
    - National instrument BNC-2100
  - Building our own computer software
## Comparison

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<thead>
<tr>
<th>Items</th>
<th>Retail</th>
<th>Est. Project</th>
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<tr>
<td>Digital Camera(s)</td>
<td>$350-$10,000</td>
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<tr>
<td>Camera Tripod(s)</td>
<td>$275-$825</td>
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<tr>
<td>Reflective Ball Markers (set of 30 passive)</td>
<td>$300</td>
<td>$105</td>
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<td>Computer Software and Computer</td>
<td>$2,500-$5,000</td>
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<tr>
<td>Force Measurement Device Components</td>
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## Comparison

<table>
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<tr>
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<th>$100-$500</th>
<th>$50-$150</th>
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<tr>
<td>Electrical Components</td>
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<tr>
<td>National Instruments PXI-1031</td>
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<tr>
<td>National Instruments BNC-2100</td>
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Conclusion

This project is unique for two reasons:

- Meets the requirement of our client
  - Adding new features that the current lab doesn’t include
  - Students will gain more knowledge about gait analysis

- The economical characteristics of the project
  - An inexpensive design
  - Under 5% of market cost