Ultrasound Displacement Sensors

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51:158 Implant Biomechanics
Sensor Types

- **Contact**: measure displacements among internal materials
- **Non-contact**: measure displacement between a sensor and a material through air
Sensor Components

- Transducer: detects ultrasonic energy and converts to a voltage and/or vice versa
- Amplifier and additional electronic components
- Computer interface
- Housing
Transducer Types

• Piezoelectric
• Electrostatic (Capacitive)
• Magnetostrictive
• Electromagnetic
• Pneumatic (whistles)
Theory

- Transmitter emits ultrasonic pulse
- Pulse is reflected at boundaries
- Receiver detects the echo
- Time from pulse emission to reflection is measured
- Object distance is determined from pulse speed (speed of sound) and reflection time
- Displacement is calculated from successive distances of the moving object
Important Considerations

• Distance between sensor and object to be analyzed
  – higher attenuation in air, attenuation increases with higher frequency

• Magnitude of Displacement
  – shorter wavelength improves measurement resolution
    • Wavelength = Speed of Sound/Frequency
    • higher frequency for better resolution
Important Considerations

• Tradeoff between resolution and attenuation
  – both frequency dependent (previous slide)
• Target material
  – topology
Applications

• Industrial
  – determine liquid levels
  – motion detector systems
  – non-destructive testing

• Biomedical
  – detect micromotion at bone-implant interface
  – measure other internal tissue displacements
  – quantify external movement during daily activities
References

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