

Short Range Tracking

MELODY research

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Workshop
May 2009

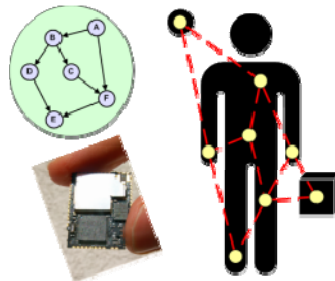


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Short-range in-body tracking

- WP4: Improved sensitivity receiver and WSN ranging engine for in-body probe tracking
- Wireless Sensor Networks – WSN
 - Body Area Networks (BAN)
 - Wireless network
 - Around body
 - Inside body
 - Mote
 - Small computer
 - ✓ Battery-operated
 - ✓ Miniaturized
 - ✓ Sensor
 - ✓ Wireless



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Example: Video endoscopy

- Looking inside your body
 - Eat video camera
 - Moving naturally through your digestion system
 - Taking pictures
 - Transmitted wirelessly
 - Require tracking
 - Special shirt
 - ✓ 14 antennas
 - ✓ At best 0.1-0.2 m resolution with current technology
 - Not good enough



Pictures from OMOM technology, China

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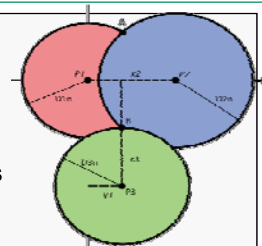


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WSN Tracking

- Localization in sensor networks
 - Measuring distance
 - Combining distances between neighbors
 - 2D localization → distances >3 neighbors
 - 3D localization → distances >4 neighbors
 - Precision increasing with number of neighbors
 - Localization in WSN (relative)
 - measuring distances between neighbors
 - For absolute localization, reference required for one node
- MELODY requirements
 - Measuring distance with motes inside and outside body
 - Outside body: multi-path components
 - Inside body: high absorption of electromagnetic waves



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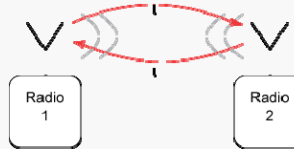


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Wireless distance measurements

- Received-Signal-Strength-Indicator (RSSI)
 - TI (ChipCon) CC2431 ZigBee transceiver
 - 2-3 m accuracy
 - Not good enough for in-body tracking
- Time-of-flight (TOF)
 - Measure propagation time of RF signal
 - But propagation speed → near speed of light
 - Hard to measure accurately
 - Especially at short range
 - Reports indicates TOF-localization at millimeter precision



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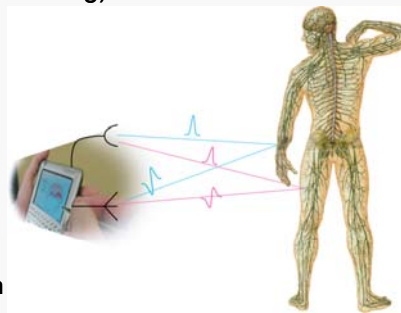


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Impulse radar

- Short Electromagnetic pulses
 - Pico-second range
 - Reflected from body (backscattering)
 - Also from inner organs
 - Passive reflection or echo
 - Very weak signals
 - Output emission limited
 - Sensitive receiver
 - Time-of-Flight
 - Distance to reflector
 - Accurate depth resolution
 - Precise temporal resolution



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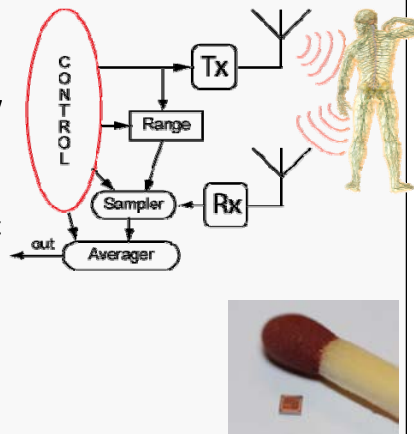


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Single-chip CMOS radar

- Transmitter
 - Emitting short pulses
- Range
 - Controlling start of depth window
- Thresholding receiver
 - Direct converting RF
- Sampler
 - Sampling 256 depths 4mm apart
 - >30GHz (>60GHz) sample rate
 - **TOF covering 60cm**
- Averager
 - Non-Coherent integration
 - Improving SNR



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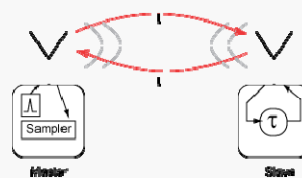


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Active Echo ranging

- Passive Echo → Active Echo
 - Master – Slave configuration
 - Master transmit trigger pulse
 - Slave actively transmit return pulse
 - ✓ After defined delay, τ
 - TOF found by subtracting τ
 - No sync required
 - Studied in MS theses at IFI 2005-2007
 - H.K.Olafsen, "Wireless Sensor Network Localization Strategies." Master's thesis, Department of Informatics, University of Oslo, Norway, May 2007.
 - N.Andersen, "Active Echo High Precision Ranging in Wireless Sensor Networks." Master's thesis, Department of Informatics, University of Oslo, Norway, May, 2007
 - Still not implemented in silicon



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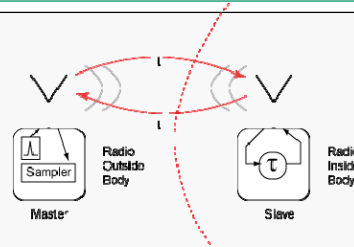


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In-body active echo ranging

- Assumption
 - Tracking slow movements
 - mm/s
- Active echo
 - Distance measurement
- Adapted High speed sampler
 - Multi-depth ranging
- Non-coherent integration
 - Averager for long integration time (many bits)
 - Lossless (digital)
 - Acceptable for slow moving targets
- Single-chip solution feasible



Difficult trade-offs: Power ↔ Tracking accuracy ↔ Sensitivity

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WSN ranging engine (WP4)

- Implement Active Echo strategy in silicon
 - Design and fab chip(s) Year 1
 - Evaluate solution in test bench
 - piggy-back PCB on mote (WP7)
- Add non-coherent integration for improved sensitivity Year 2
 - Design and fab
 - Adjust for WP3 results for best frequency range
 - Evaluate in test-bench

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