UWB Active Echo Ranging Engine

MELODY research

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Workshop on
UWB Implementations
2010-06-08

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Outline

- Short-range in-body tracking
  - WSN tracking
  - Wireless distance measurement
- CTBV domain
- Impulse Radar
  - CTBV impulse radar
- Active-echo Radar
  - Active Echo ranging engine
  - Chip prototype
- Conclusion and further work

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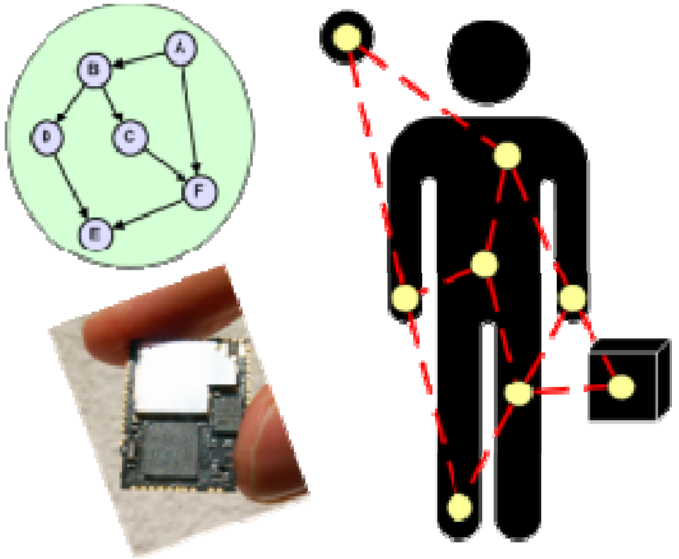
Short-range in-body tracking

- Melody Project, 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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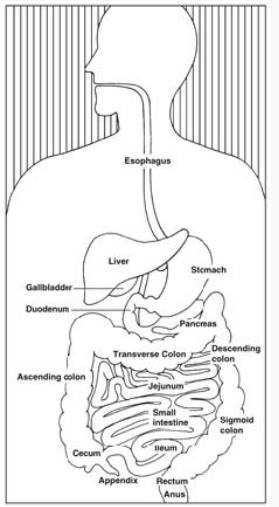
Example: Video endoscopy

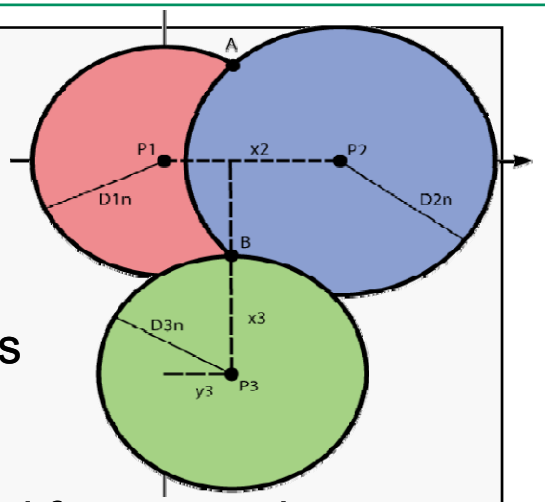
- Looking inside your body
  - Eat video camera
  - Moving naturally through your digestion system
  - Taking pictures
    - Transmitted wirelessly
  - Require tracking
    - Special shirt
      - ✓ 14 antennas
      - ✓ At best 0.1-0.2 m resolution with current technology
    - Not good enough



Pictures from OMOM technology, China

WSN Tracking

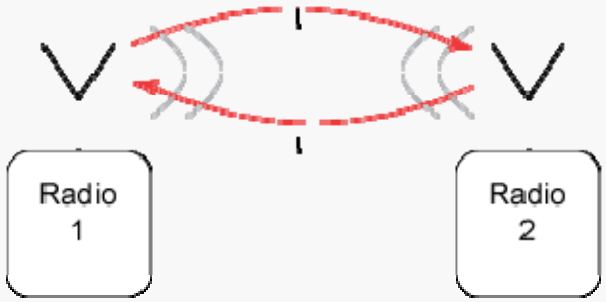
- Localization in sensor networks
  - Measuring distance
  - Combining distances between neighbours
    - 2D localization → distances >3 neighbours
    - 3D localization → distances >4 neighbors
  - Precision increasing with number of neighbours
  - Localization in WSN (relative)
    → measuring distances between neighbours
    - 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

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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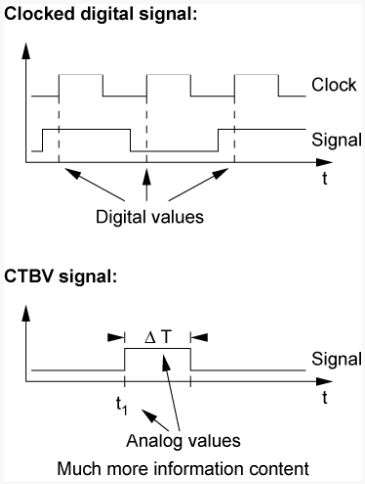
CTBV domain

- Time domain processing
  - Really fast
    - 90nm → 12ps inverter delay
  - Low power supply
    - 1V → binary values
- Continuous Time – Binary Value

Time

Value	Discrete	Continuous
Binary	Digital	CTBV Neuromorphic/spike
Continuous	Analog sampled–data (switched–cap)	Analog

  - No high speed clock
    - Power efficient



New design paradigm

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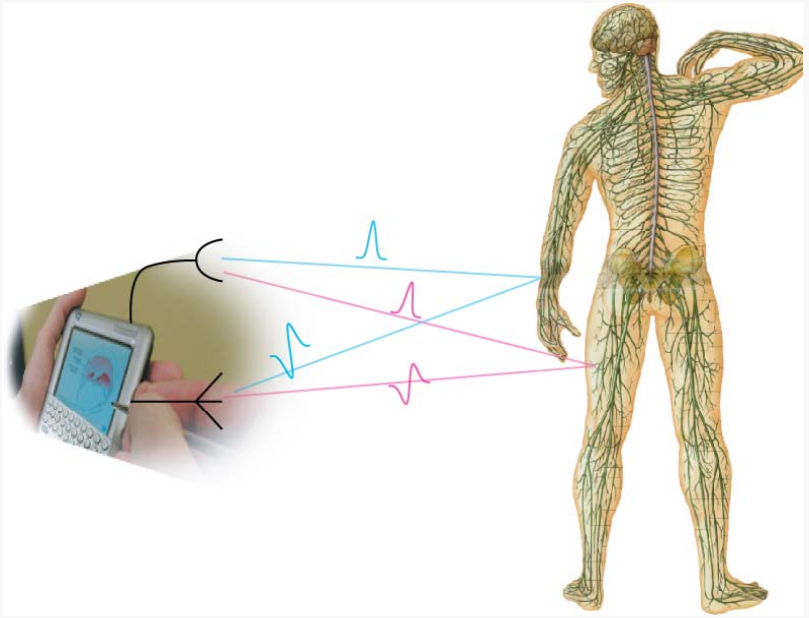
Impulse radar

- 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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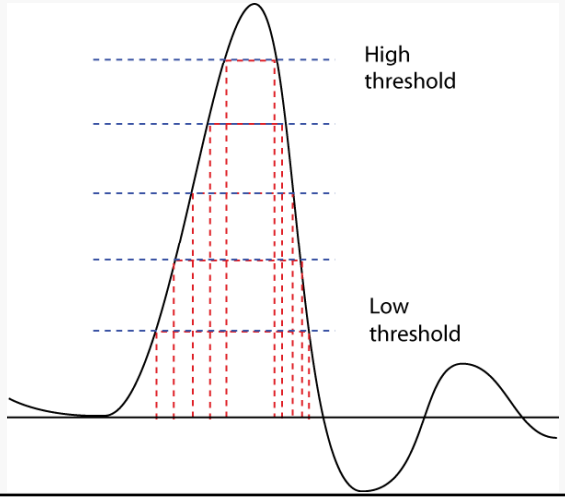
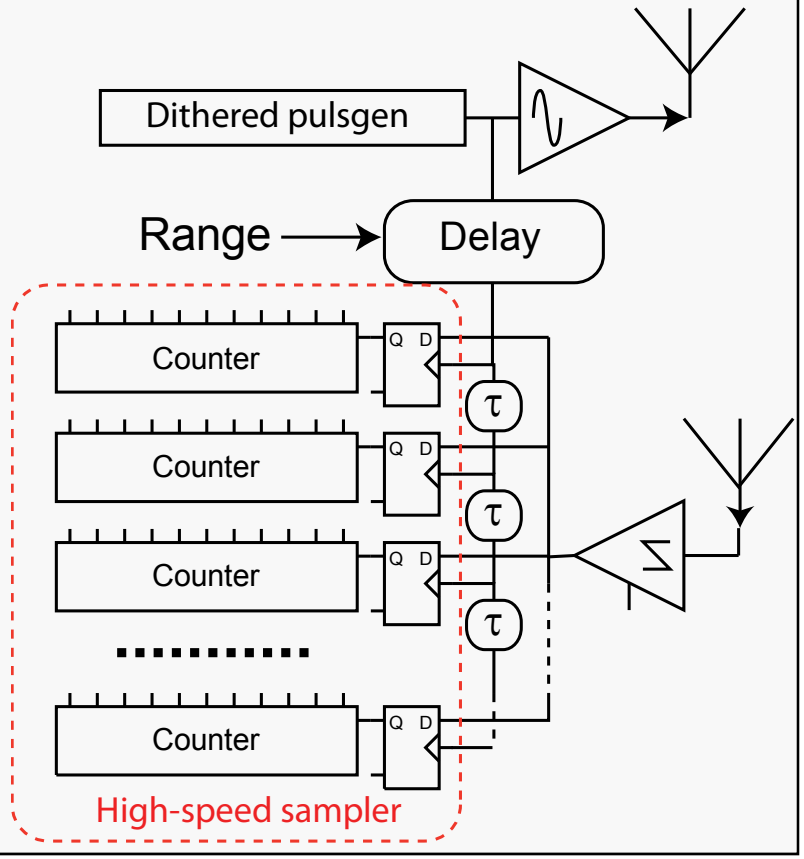
CTBV Impulse Radar

- Exploring
  - Swept Threshold Sampling
  - Fast sampler using CTBV delayline
    - inverters
  - Lossless integrators
    - counters





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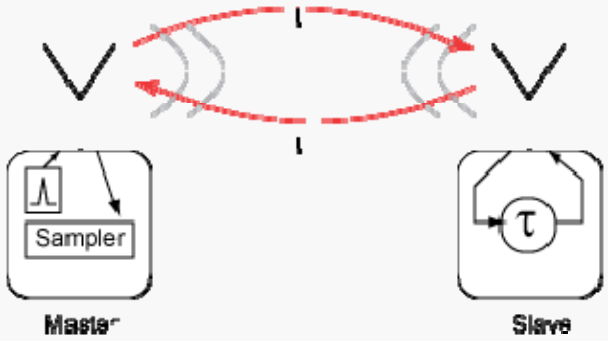
Active Echo ranging

- Passive Echo → Active Echo
  - Master – Slave configuration
    - Master transmit trigger symbol
    - Slave actively transmit return symbol
      - ✓ After defined delay, τ
    - TOF found by subtracting τ



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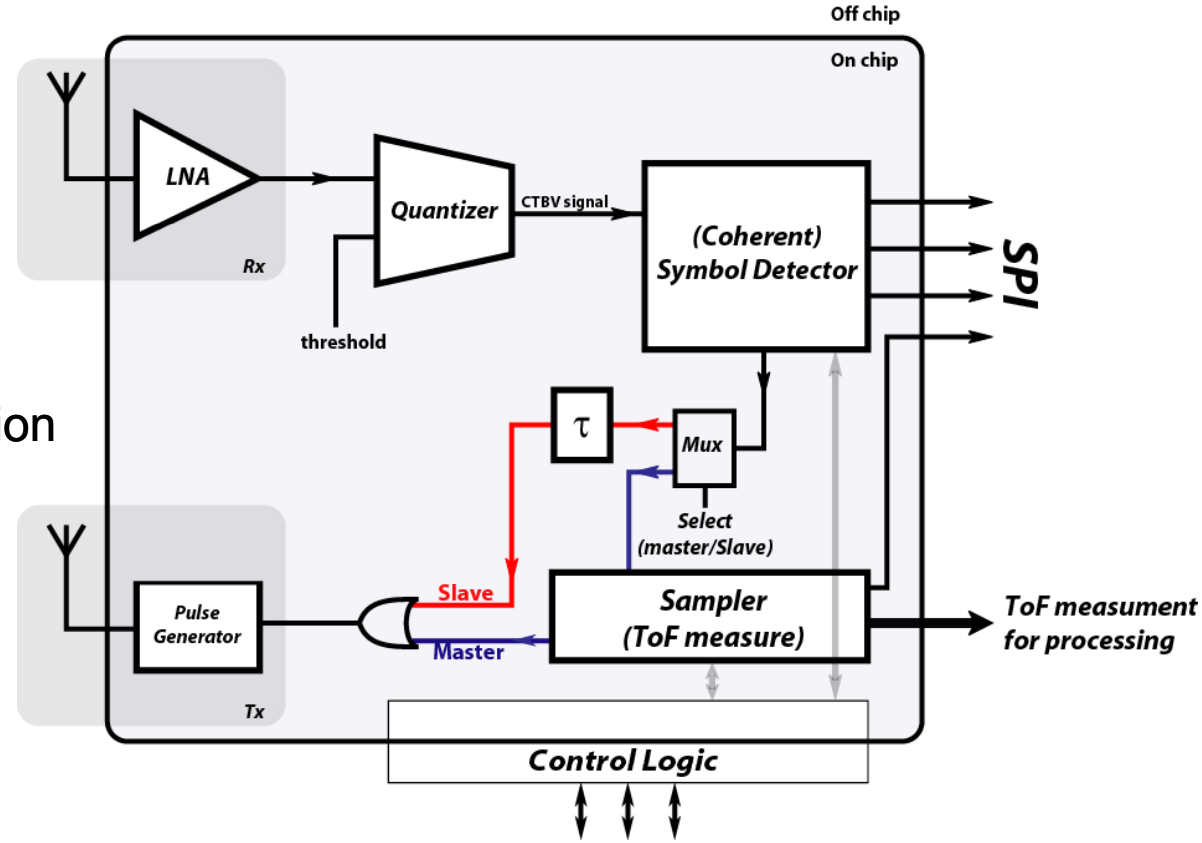
Active Echo Ranging Engine

- Front-end
  - Convert incoming RF pulses to CTBV signal
- Symbol Detector
- Master/slave configuration
- Sampler



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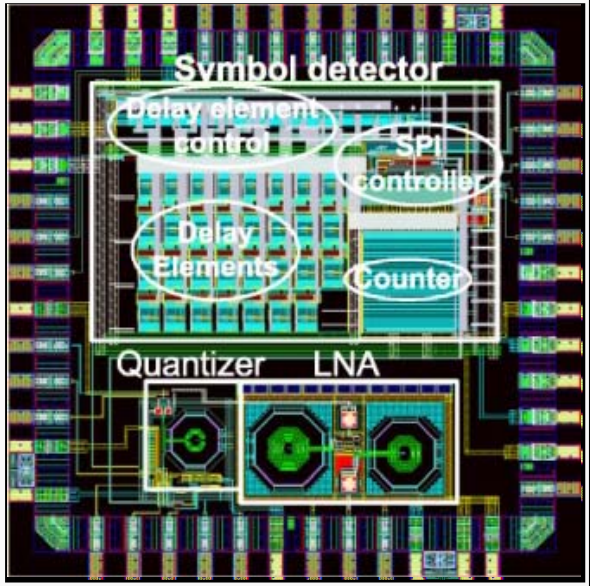
Chip Prototype 1

- Chip submitted November 2009
- TSMC 90nm LP CMOS process
- Include
  - Front-end
    - LNA
    - Quantizer

    T.A.Vu, S. Sudalaiyandi, M.Z. Dooghabadi, H.A. Hjortland, Ø. Næss, T.S. Lande and S-E Hamran **"Continuous-Time CMOS Quantizer for Ultra-Wideband Applications"**, *The IEEE Int. Symp. On Circuits and Systems (ISCAS 2010)*, May 30th – June 2nd 2010, Paris, France
  - Symbol Detector

    S. Sudalaiyandi, M.Z. Dooghabadi, T.A. Vu, H.A. Hjortland, Ø. Næss, T.S. Lande and S-E Hamran "***Power-Effiecient CTBV Symbol Detector for UWB Applications"*** *Accepted for the 2010 IEEE Int. Conf. on Ultra-Wideband (ICUWB 2010),* Sep. 20-23 2010
- Measurements starts June 2010
- Next version scheduled for Oct./Nov. 2010



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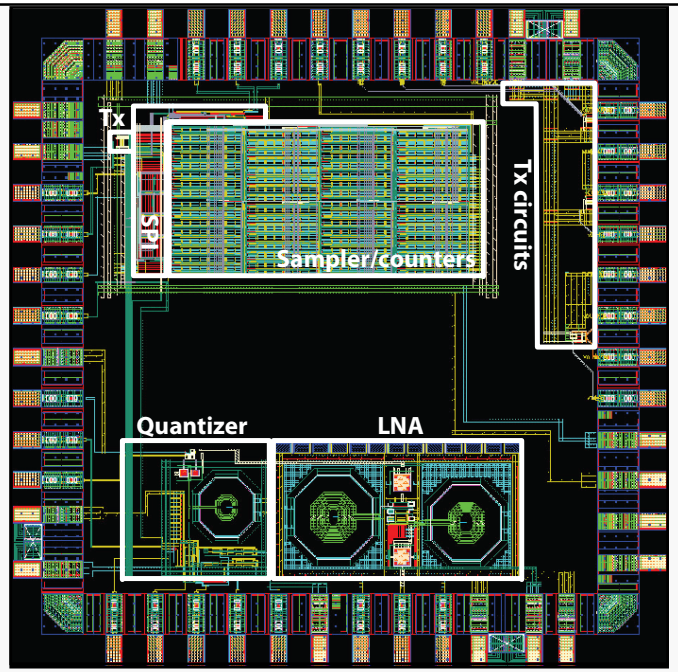
Final blocks

- Chip including
  - Sampler
  - Transmitter
  - Front-end
- Submitted April 2010
  - Expected received June/July 2010
  - Measurement from July 2010



Sampler/transmitter also designed by persons outside Melody Project

- **M.Z. Dooghabadi, A.T. Vu, S. Sudalaiyandi, H.A. Hjortland, T.S. Lande, Ø. Næss, S-E. Hamran - "*Electromagnetic Impulse Radio Camera*"** *Proc. 27th Norchip Conf., Tr.heim, Nov.16.-17 2009. IEEE conf. proc. 2009 ISBN 978-1-4244-4311-6*

Conclusion and further work

- A UWB Active Echo Rangine Engine scheme has been presented
- RF to CTBV convertion (Quantizer)
- Coherent Symbol detector
- All parts have been processed and will be verified within 2010

- Further work
  - Redesign and respin of prototype is scheduled for submission Oct./Nov. 2010
    - Including transmitter and sampler

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