

Contact-free Sensing for collective Activity Recognition

Stephan Sigg

Georg-August-University Goettingen, Computer Networks

Shonan meeting on Challenges in real-time AR

07.09.2015

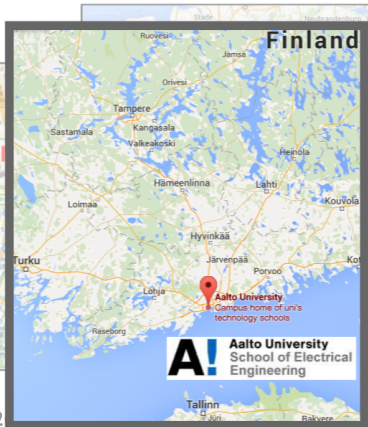




GEORG-AUGUST-UNIVERSITÄT
GÖTTINGEN



- Founded 1732/1734
- Excellence initiative: 2007 to 2012
- 2nd highest ranked German University (World University Rankings 2013/2014 (Times Higher Education))
- > 25.000 Students
- 5 MPIs

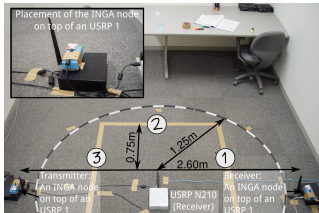


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RF-based device-free activity recognition



Active SDR-based DFAR (USRP1)

Frequency: 900MHz (RFX900 board), Vert900 Antenna), 4dBi antenna gain
Signal: Sine signal, continuously modulated onto the carrier
Sample rate: 80 Hz



Passive SDR-based DFAR (USRP N210)

Frequency: 82.5MHz (WBX board), Vert900 Antenna, 4dBi antenna gain
Signal: Environmental FM radio captured from a nearby radio station
Sample rate: 64Hz



Active RSSI-based DFAR (INGA wsn nodes, v1.4)

Frequency: 2.4GHz IEEE802.15.4, PCB High Gain-Antenna
Signal: RSSI samples from packets transmitted between nodes
Sample rate: Transmission of 100 packets per second



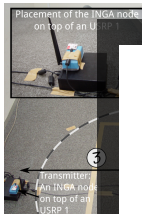
Accelerometer-based activity recognition (Iphone 4)

Signal: 3-axis accelerometer
Sample rate: 40 Hz

	Active				Passive			
RSSI-based	Continuous signal				Continuous signal			
	Tx	Rx	# receive devices cf. [13]	multiple subjects cf. [13]	Localise activities cf. [20]	LTE	UWB	# receive devices
						WiFi	Wimax	multiple subjects
						FM	60M	Localise activities
RSSI-based	Discrete signal				Discrete signal			
	speed (dynamic activities)	multiple frequency bands in [13]	training in new environ.	recognise activities cf. [13,20]	speed (dynamic activities)	multiple frequency bands	training in new environ.	recognise activities cf. [19]
	Tx	Rx	# receive devices in [14]	multiple subjects	Localise activities			# receive devices
								multiple subjects
RSSI-based	Discrete signal				Discrete signal			
	speed (dynamic activities)	multiple frequency bands	training in new environ.	recognise activities cf. [14]	speed (dynamic activities)	multiple frequency bands	training in new environ.	recognise activities

walking
standing
Crawling
Lying
empty

RF-based device-free activity recognition



Active SDR-based DFAR (USRP1)
Frequency: 900MHz (RFX900 board), Vert900 Antenna, 4dBi antenna gain

		Classification			
		lying	standing	walking	crawling
Ground truth	ly	.976	.024		
	st		1.0		
	wa			.955	.045
	cr			.253	.748

(a) Classification accuracy for accelerometer-based activity recognition by a k-NN

		Classification			
		lying	standing	walking	crawling
Ground truth	ly	.904	.096		
	st	.096	.898	.006	
	wa		.013	.962	.025
	cr		.038	.212	.75

(b) Classification accuracy for active SDR-based DFAR by a k-NN algorithm

		Classification			
		lying	standing	walking	crawling
Ground truth	ly	.882	.118		
	st	.12	.869	.007	.004
	wa			.953	.047
	cr		.01	.439	.551

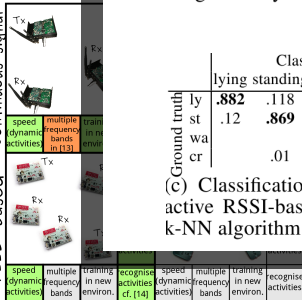
(c) Classification accuracy for active RSSI-based DFAR by a k-NN algorithm

		Classification			
		lying	standing	walking	crawling
Ground truth	ly	1.0			
	st	.056	.98	.022	
	wa	.023		.874	.102
	cr	.044	.144		.811

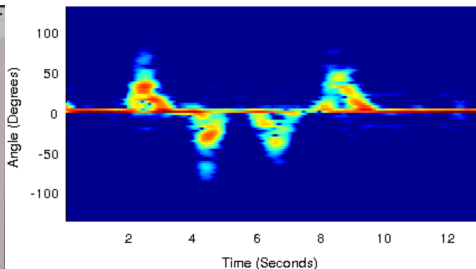
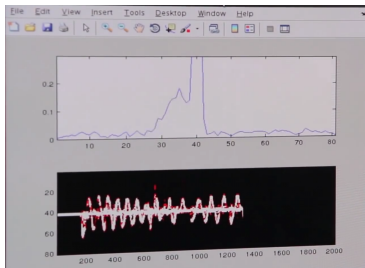
(d) Classification accuracy for passive SDR-based DFAR by a k-NN algorithm

Continuous signal

RSSI-based



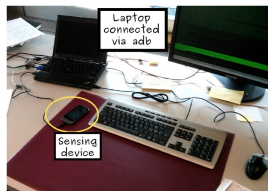
Recent related work



Whole-Home Gesture Recognition Using Wireless Signals, Q. Pu, S. Gupta, S. Gollakota, S. Patel, Mobicom'13

See Through Walls with Wi-Fi!, F. Adib, D. Katabi, SIGCOMM'13

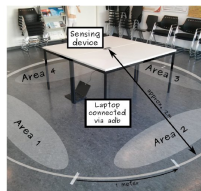
Situation and gestures from passive RSSI-based DFAR



(a) Office environment at ETH



(b) Lecture room at TU-BS



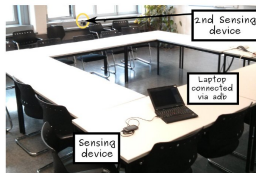
(c) Scenario for the distinction of walking speed



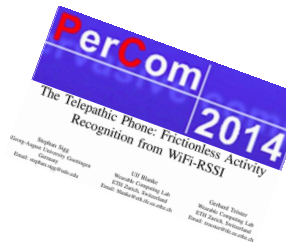
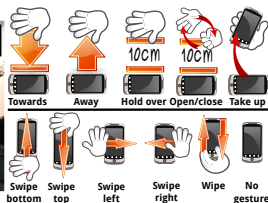
(d) Activities conducted behind a closed door



(e) Sensing device inside pocket



(f) Meeting room at ETH



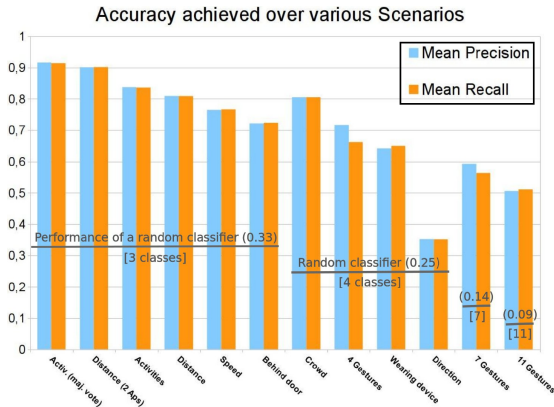
Situation and gestures from passive RSSI-based DFAR



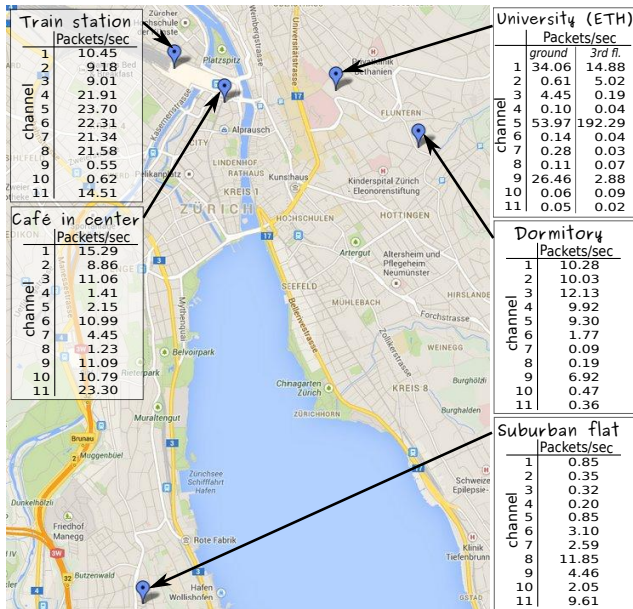
(a) Office



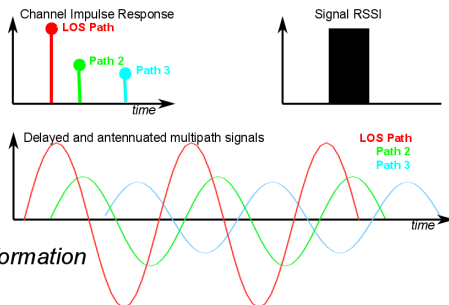
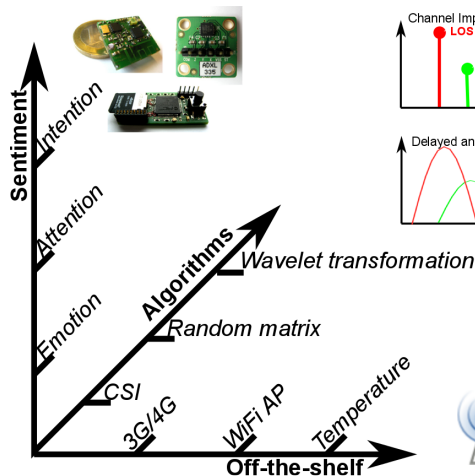
(d) Activities conducted by



Which sample rate can we expect?



Sensing and recognition



Crowd + flow
monitoring/prediction



Q+A

stephan.sigg@udo.edu