



Information and Communication Technologies for Precision Agriculture: SuPPReSS Case Study

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Cacak, Serbia, March 10-11, 2017

22nd INTERNATIONAL SYMPOSIUM ON BIOTECHNOLOGY



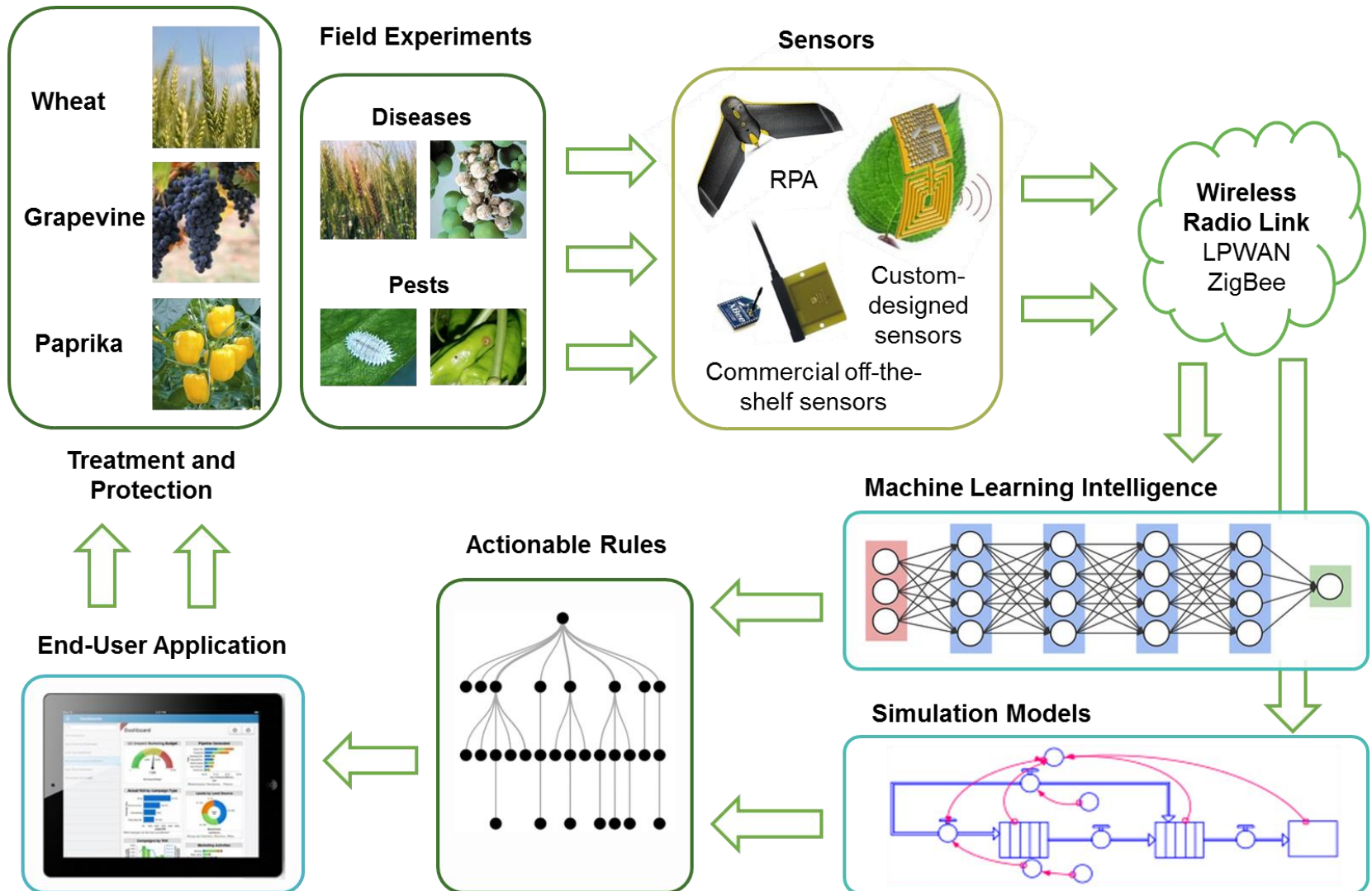
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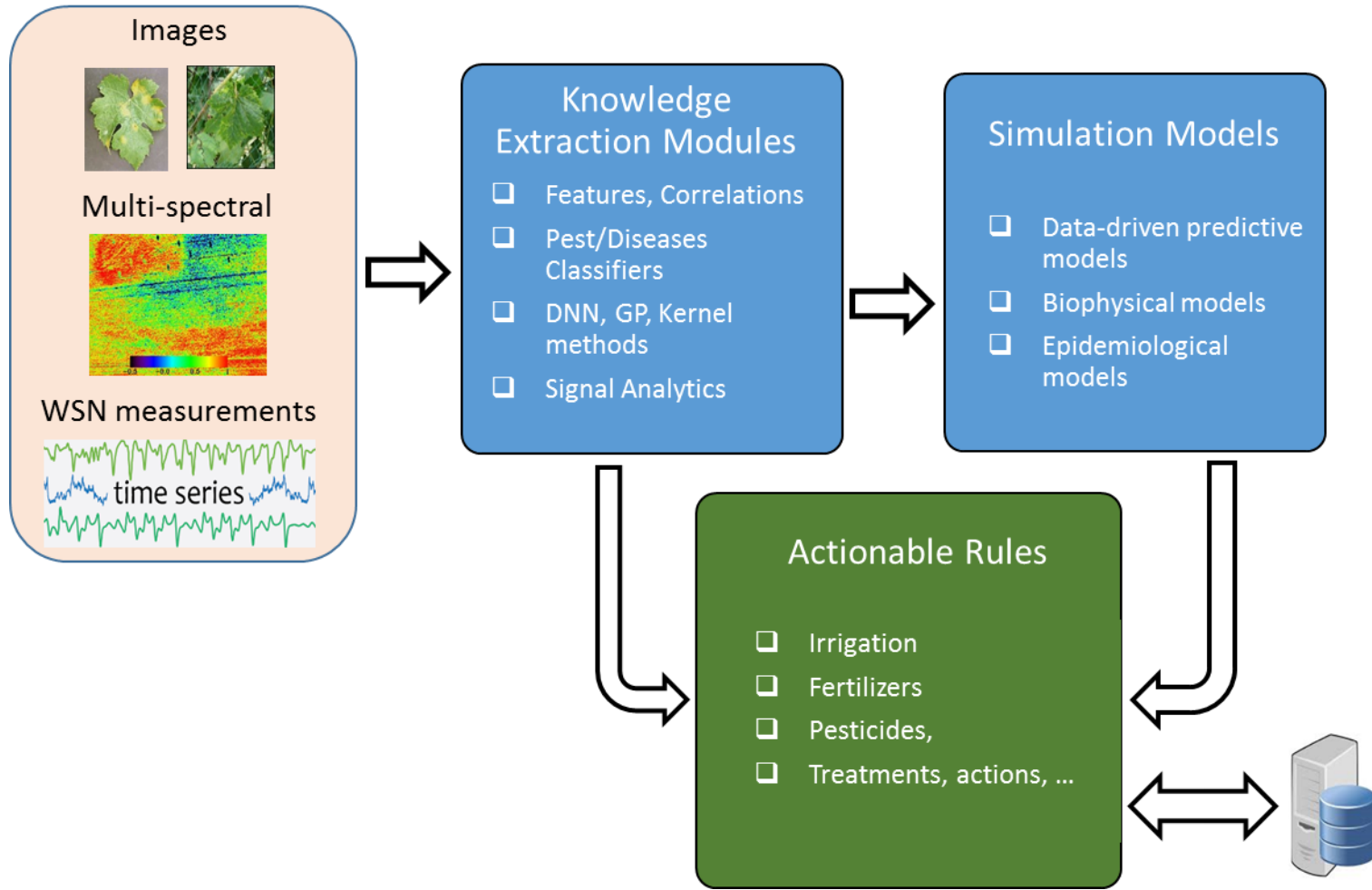
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SuPPReSS Technology (1)



SuPPReSS Technology (2)



Simulation Model Inputs - Variables

Variables	Wheat	Grapevine	Pepper
Meteorological variables	Temperature, humidity, rainfall, wind speed, and insolation	Temperature, humidity, rainfall, wind speed, and insolation	Temperature, humidity, rainfall, wind speed, insolation, and atmospheric CO ₂ concentration
Crop variables	Phenology, above-ground biomass	Phenology, above-ground biomass	Phenology, above-ground biomass, partitioning of biomass into crop organs
Management information	Previous crop, variety, cropping practices, fertilization, and harvest date	Variety, cropping practices, irrigation rate, fertilization, and harvest date	Previous crop, variety, cropping practices, irrigation rate, fertilization, harvest date
Pest and disease effects	Yield loss caused by disease, infected leaf area (STB) or heads (FHB)	Percentage of grapes, leafs and stems affected by disease	Number of dropped fruits and destroyed plants, percentage of crops affected by pests
Soil variables	Soil moisture (at specific depth), soil texture, and organic matter content	Soil moisture (at 5 cm and 20 cm depth)	Moisture, clay, sand, organic matter content, C to N ratio, pH (CaCl ₂), Ca content
Nutrients concentration	Nitrogen concentration in leaves	Nitrogen concentration in leaves	N and Ca in leaves and fruits
Leaf variables	Leaf wetness and temperature, leaf area index	Leaf wetness and temperature, leaf area index	Leaf wetness and temperature, leaf area index
Quality	DON (deoxynivalenol) concentration	Colour, sugar, acidity and pH in fruit juice	Sugar, acid, and capsaicin content in hot varieties, vitamin C, total phenols, and phenolic acids

Simulation Model Inputs - Images

Images	Wheat		Grapevine		Pepper	
	FHB	STB	Mildew	Citrus mealybug	CBW/ECB	GPA
Multispectral data taken from RPA (four spectral bands)	Bleached heads	Long-stretched patterns	Yellowish patterns on the upper surface of leaves	Leaf-roll Defoliation		
Thermal data taken from RPA (four spectral bands)	Bleached heads	Discoloured leaves Necrotic area Chlorotic area around lesions	Yellowish patterns on the upper surface of leaves	Leaf-roll Defoliation		
RGB images	Portion of head infected	Portion of leaf area diseased	Portion of non-green leaf area	Portion of non-green leaf area	Larvae on stem and fruits Egg on both sides of leaf Position of fruits and dropped fruits	Colony on plant tips Ant colony Fruit colour and shape Portion of non-green leaf area
Trap photos				Sticky bases	Sticky bases	Yellow traps

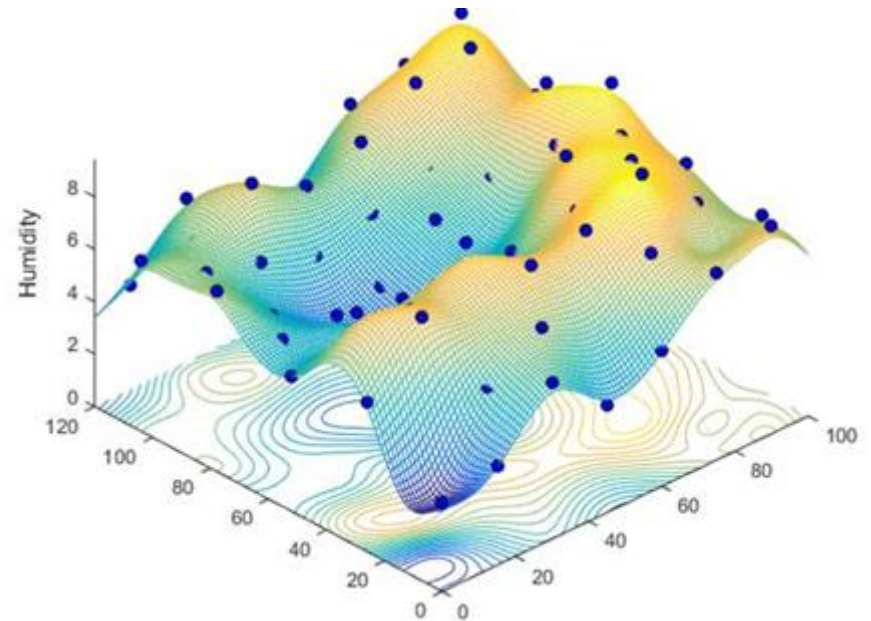
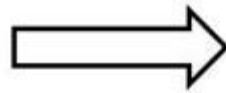
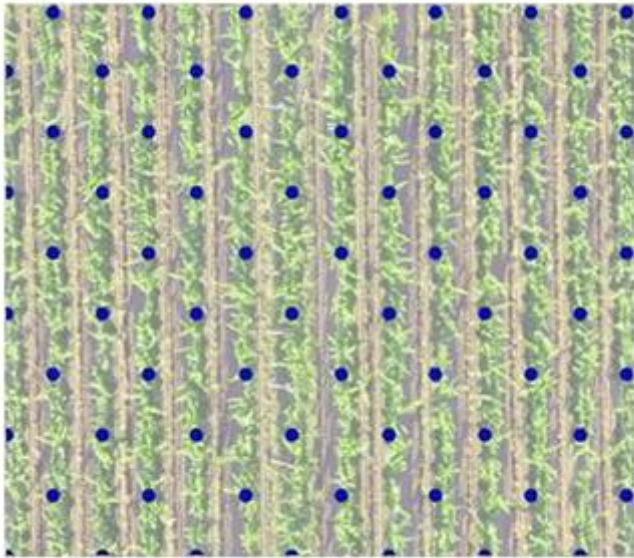
Gaussian Processes

For regression/interpolation problems in spatio-temporal fields

Measure of the similarity between points (this is the kernel function)

Predict the value for an unseen point from training data

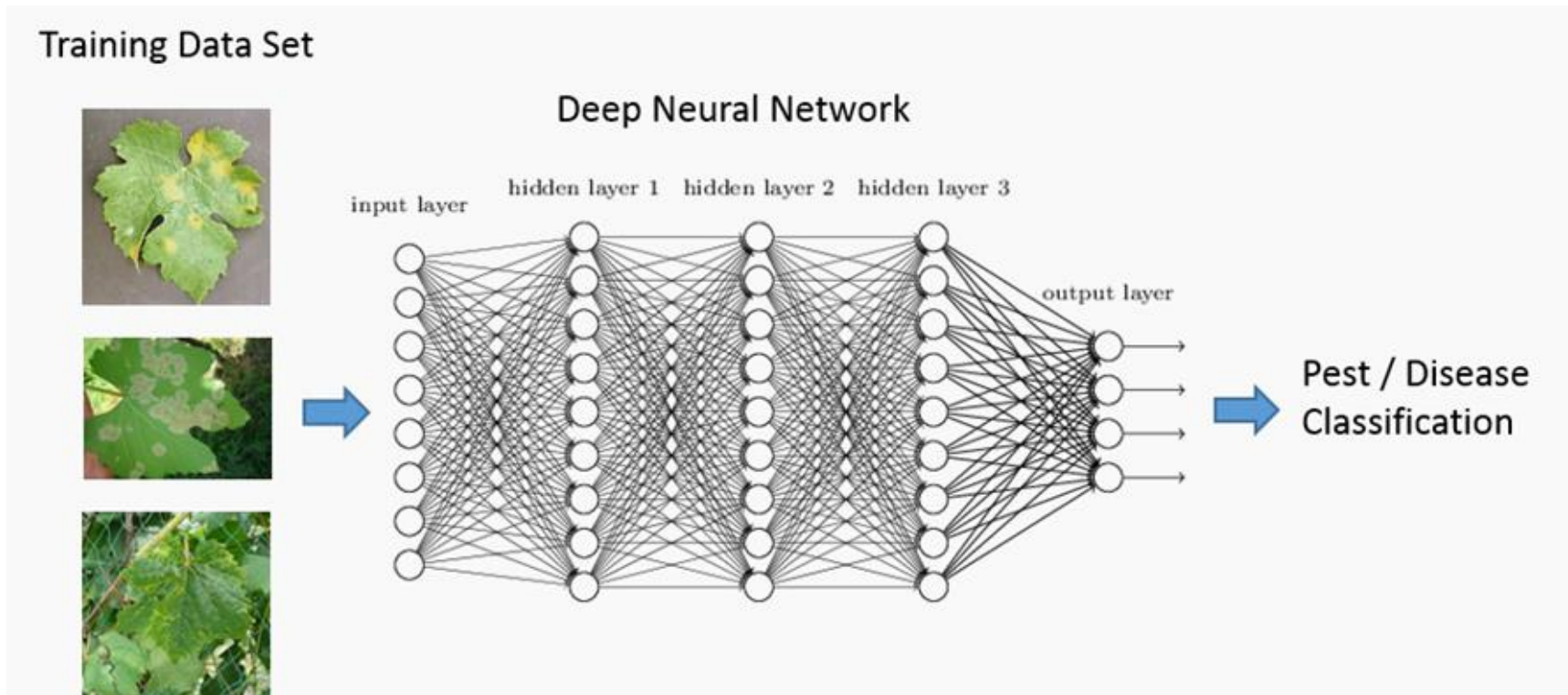
Prediction is the estimate for unseen point with uncertainty information



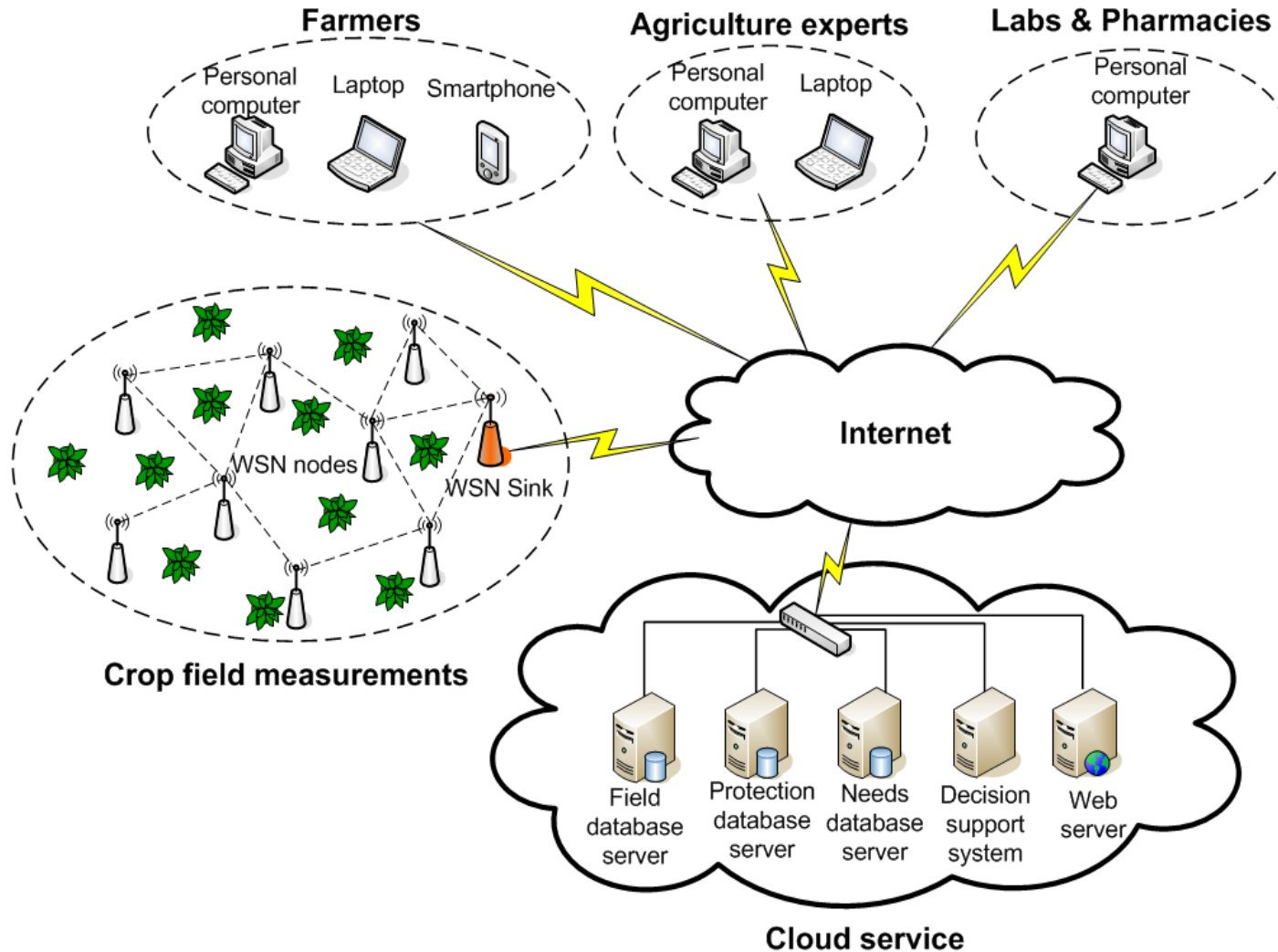
Deep Neural Networks

Cascade of multiple layers of simple nonlinear processing units

Weights of interconnections are adjusted during network training



SuPPReSS Decision Support System



Wireless Sensor Nodes - Properties

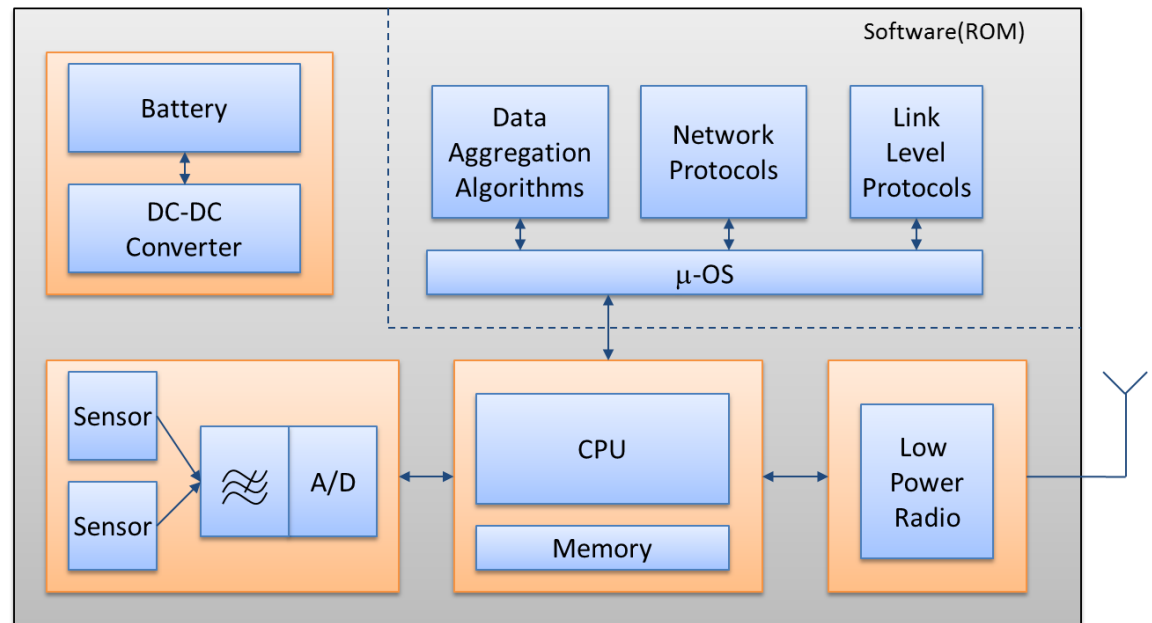
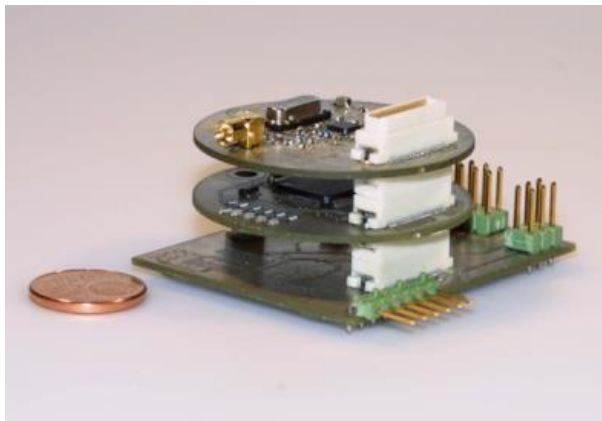
Lifetime operation with a single battery charge

Diversity of applications

Low duty cycle

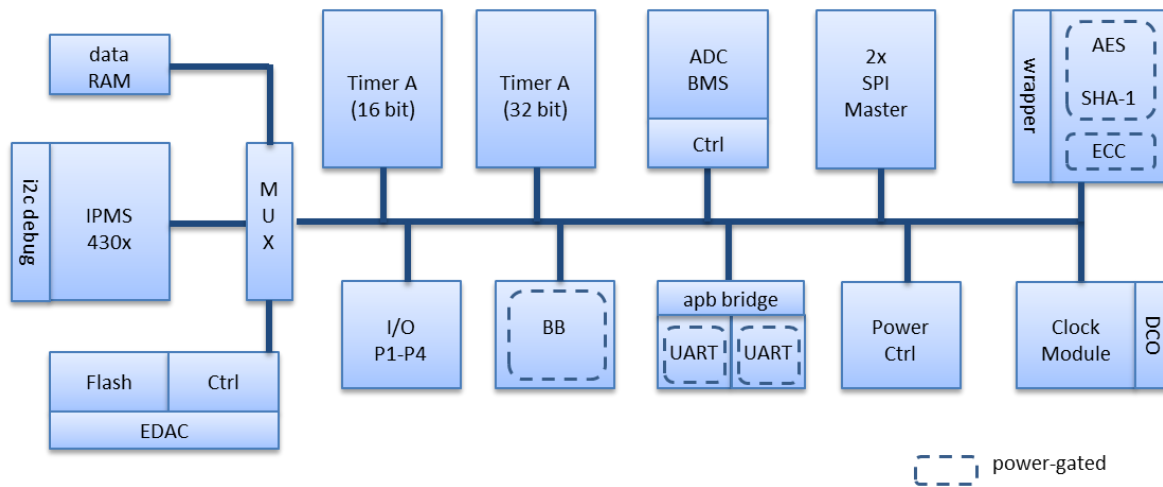
Small size

Low cost

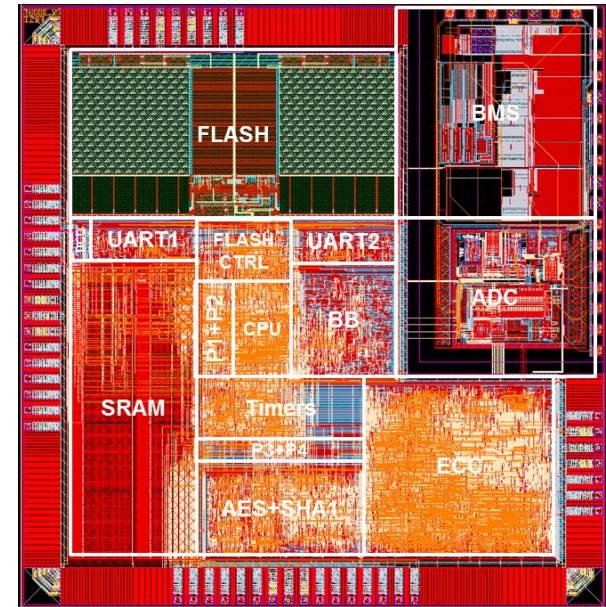


Design challenges: energy consumption vs performance vs cost

TNODE Processor



Operation	Logic (mW)	ADC (mW)	Flash (mW)	Total (mW)
SHA-1 Calculation	0.98	6	7.6	14.58
AES Decryption	1.18	6	7.6	14.78
AES Encryption	1.25	6	7.6	14.85
ECC Point Multiplication	2.68	6	7.6	16.28
ECC First Point Inversion	2.11	6	7.6	15.71
ECC Second Point Inversion	2.06	6	7.6	15.66
Transmit Mode	0.69	6	7.6	14.29
Receive Mode	0.71	6	7.6	14.31
SPI	0.98	6	7.6	14.58



Technology: 250 nm BiCMOS

Area: 31 mm²

Pads: 71

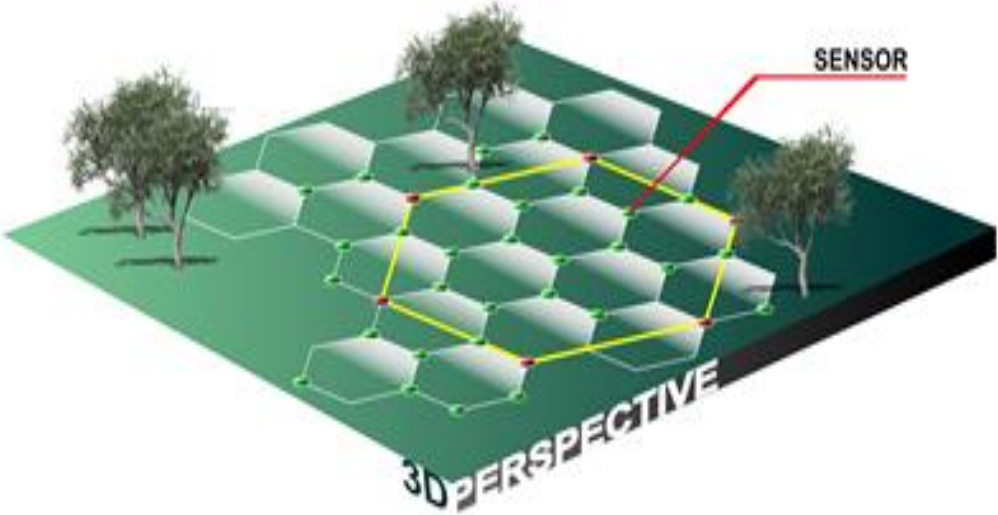
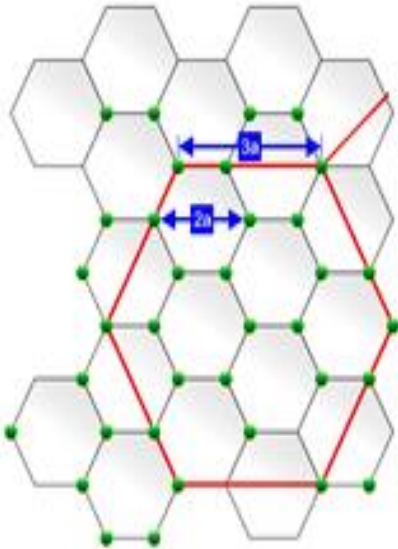
Frequency: 11.4 MHz

Peak Power at 1 MHz:

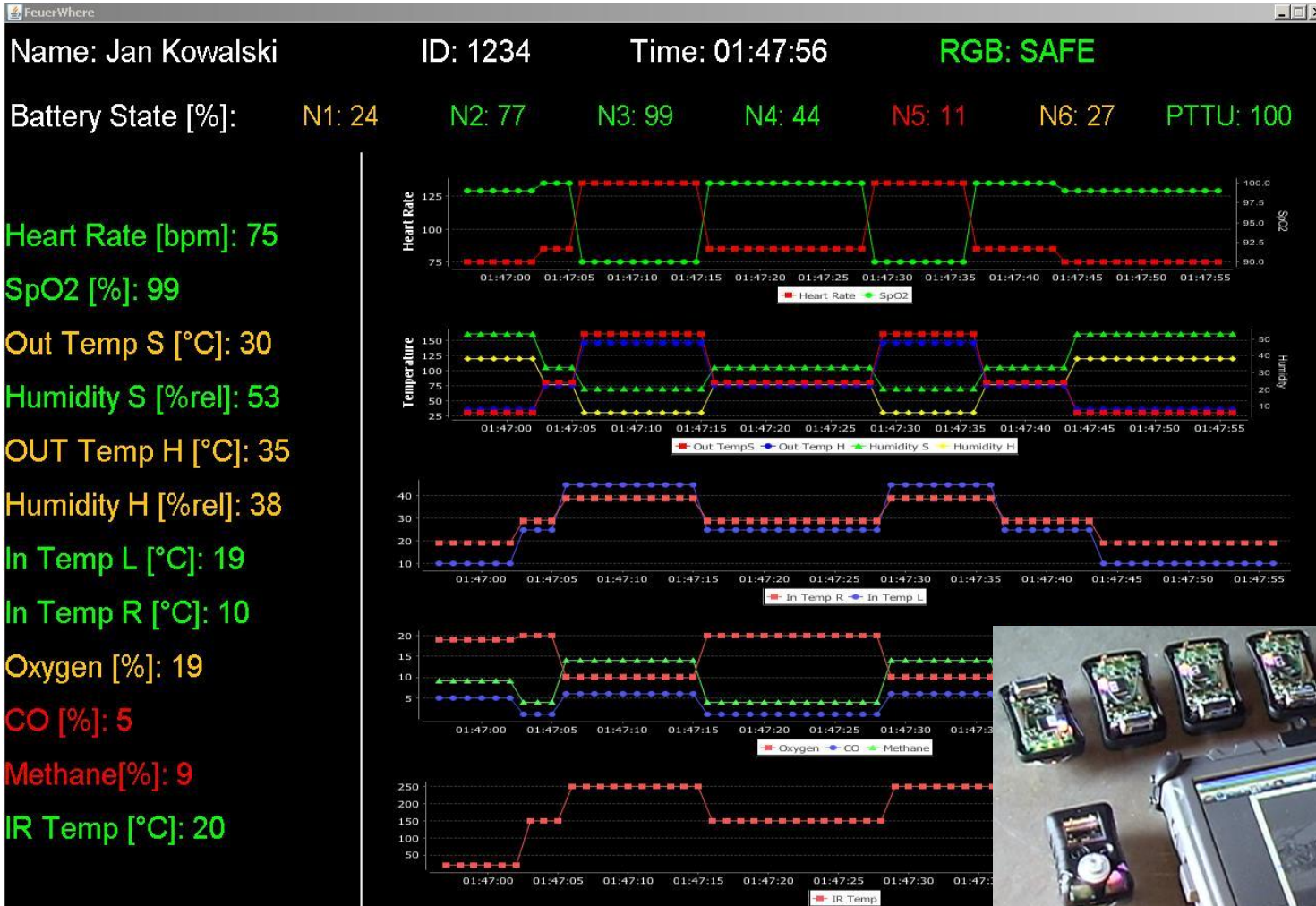
- 52 mW (ADC on)
- 10 mW (ADC off)

G. Panic, O. Stecklina, and Z. Stamenkovic, "An Embedded Sensor Node Microcontroller with Crypto-Processors", *Sensors*, vol.16, pp.60701-60719, 2016.

Sensor Deployment



Demonstrator





Thank you for your attention!

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