### Fully Wireless Insoles for Monitoring Fall risk Index (FRI)

Joint Medical + ICT R&D Experience in the framework of the FP7 European Project Wiisel (www.wiisel.eu)

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#### WIISEL (FP7 – ICT) Project Facts & Figures

- Title: Wireless Insole for Independent and Safe Elderly Living
- Period: 1/9/2013 to 31/3/2015
- Budget: 3.9M€ (2.9M€funding)
- Web site: www.wiisel.eu
- Leader: CETEMMSA (now EURECAT)
- 8 partners + 3 subcontractors





WP 2

WPs 1-2-4

WPs 1-2-3



#### WIISEL Final VIDEO.mov



TRL = Technology Readiness Level

# Commercial Solutions for Wireless Motion Detection & Gait Analysis

Device name and company	Application	Sensors	P [kPa] Range	RA <sup>1</sup> [KPa]	IE <sup>2</sup>	Acq <sup>3</sup> [Hz]	D <sup>4</sup>	BA <sup>5</sup> [h]	Price
WII SE L	Continuous gait monitoring, analysis and fall risk assessment	piezoresistive (14) Inertial	350	0.34	Yes	33.3	BLE	16	Pending
Pedar By Novel	Footwear design and injury prevention	pressure (99)	600	2.5	No	100	BT	1	15,450€
F-Scan (in sole) By Tekscan	gait analysis & biomechanics, diabetic offloading , sports medicine	pressure (960)	862		No	165	USB Wifi	0.2	16,000\$
BioFoot By IBV	Sports Gait analysis Footwear design	pressure (64)	1200	0.1	No	500	Wire WiFi	1	12,995€
paroLogg/paro Tecc by paromed	Foot pressure analysis	Pressure (32) Inertial	625		No	300	Wifi	1.5	
Foot Pressure MS By Medilogic	Gait, Sports, Health Prevention, Prosthesis and Orthotics, Diabetics	SSR sensors (240)	640		No	300	Wirel ess		
Sm a rtStep™	rehabilitation process				No		Card		6,000\$
SmartInsoles <sup>™</sup> By 24eight, LLC	medical, sports and gaming	Pressure (4) Inertial	241		Yes		wirel ess	~100	
Op enGoscience By Moticon	Medical and sports science Rehabilitation and training analysis	Pressure (13) Inertial, Temp	400	2.5	Yes	100	Wire- less		2,000€
Footswitches Insole from B&L Engineering	G ait analysis	4 pressure sensors			No		Wire- less		299\$ + 9,000\$ SW
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<sup>1</sup> Resolution & Accuracy,<sup>2</sup> Integrated Electronics,<sup>3</sup>Max Data acquisition rate, <sup>4</sup> Data Transfer Type, <sup>5</sup>Battery Autonomy

#### WIISEL Wireless Insoles











#### **Electronics**

14 pressure sensors 3D Gyroscope/Accelerometer Flexible PCB Semiflexible Battery Bluetooth low energy 4.0 Qi Inductive charge









#### System Description

- A wearable and
   Easy to wear, c
- Continuously ca
  - stride time, sing steps per day, st pressure values
- To obtaing Larg <u>– Real-life & lon</u>
- With a highly p
- That allows a P



# Patient/Clinician



#### Utility: Validation

- Refers to the ability of the product to perform a task
- Elderly volunteers at 3 clinician sites
- Addressed aims:
  - (1) Assess the comfort and durability of the insole,
  - (2) evaluate the **functionality** in **collecting gait data**,
  - (3) measure & recognition of walking patterns, activity and sedentary periods and to identify risky behaviors,
  - (4) assess the users' feasibility to operate at home
  - (5) evaluate the usability
  - 2 clinical phases:
    - Pilot: 3 days of assessment (1 in a laboratory + 2 at home)
    - Validation: ~2 weeks for patient's daily living with weak support

#### Usability: Patients

- Extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use
- Patient: Comfort Wearing Insoles + Smartphone
  - 6 experts carried out an ergonomic inspection of insoles
  - 10 volunteers carried out a controlled comfort study
  - App UI Evolution

	0 🗢 1	13:51	`	5	3		Settin	gs	General is ON	SEL Mode
Device State	e Signal	Charge			-	e	Device Wiisel_Right	State	Signal	Charge
Insole First insole Second insole Timer Number of steps Walking distance	0/0 0/0			Ĩ			Right insole Left insole Number of s Walking dis	steps	132 134 0.0 0.0 m 0.0 min	

#### Usability: Clinicians

#### • Clinicians:

- Complete collection of gait parameters
- Robust against Connection breaks
- Fall detection without false positives
- New FRI with sensitivity parameters
- Results consistent with "gold" Standards
- Big Data Architecture for parallel uploads
- Individual Fact sheet

figuration Options Info						
Data input selection	Raw data filtering	Gait parameter definition	Gait parameter history	Pattern extraction	all Risk Index definition	Fact sheet
ct Fall Risk Index	Fall Risk Index settings					
el	Selected pattern	Weight [%] Minimum impact [%]	I	Distribution of pattern [%]		
12	SingleSupportLeft	31 71	1			
skindex	HeelStrikeForceSlopeLeft	5 0				
	AvgAccelerationAmplitudeML	12 0				
	DoubleSupportRight	52 0				
w Edit Delete	Weight all equally	Find best weights				HeelStrikeForceSlopeLeft AvgAccelerationAmplitude DoubleSupportRight
patterns S efStrikeForceSlopeLeft variation	Fall Risk Index details for each s	ubject SingleSupportLeft (Weight: 31%)	HeelStrikeForceSlopeLeft (Weight 53	AvgAccelerationAmplitudeML (Weix	ht DoubleSupportRight (Weight 53	1%1 Fallrisk index
gHeelStrikeForceSlope	nkco ogota 34	62.37%	100%	39.75%	0%	29.1
elStrikeTcFlatPhazeRight variation	octkpc dtalian 35					
ubleSupportRight	<ul> <li>Dtkfikf Jgyctf 36</li> </ul>	8%	0%	6%	0%	0
celerationAmplitudeMLLeft variation	n Vap(Mgcpg 37					
celerationAmplitudeAPLett	Florpc Jincpt 40	0%	100%	100%	0%	17
celerationAmplitudeVerticalLeft	Eltkuvkpc Qitgp 42	100%	49.82%	6%	0%	75
bacessamuna burgear	Cppc"Octkc Ictgnnk 44	77.72%	65.13%	96.41%	0%	25
sk index ranges	Gptkec Ucuugnk 45					
	Octkuc Ueqtugvvk 46	93.93%	100%	100%	0%	71
from to	Icnkpc Uclgigwtum{ 48	0%	0%	100%	0%	12
70 2 100 2	Octko Tkeek 49	100%	73.48%	100%	108%	98.57
10 18 100 18	engzepfgt htgpmgn 50	100%	100%	100%	0%	71
* 30 % 70 %	Octke Uwre 51	93.53%	32.38%	100%	100%	34.61
0 2 30 2	Toeign Duecpftcpk 54	0%	100%	100%	100%	69
	T goop Dtglign 55	0%	100%	0%	0%	5
Update	Nvido Ujint 56	7.72%	51.9%	100%	0%	16,99
	Florpc J{ncpt 59	1.06%	100%	100%	0%	17,33
	Nikco Oggtg 60	14.73%	42.29%	0%	0%	6,68
	Vap{ Mgcpg 61	8.17%	0%	6%	8%	2,53
	octic 'nklike uknxgvvk 63	100%	100%	100%	0%	7
	ctigpvkpc ekitkcpk 64	54.51%	100%	100%	0%	33,9
	Dgtpc 66	0%	100%	100%	0%	17.
	Gpfc Ecorkqp 67	0%	0%	0%	0%	0
	xongt( mov/ 69	92.7%	100%	100%	0%	71
	0 D 70	0%	0%	100%	0%	12
	J D 73	7.82%	0%	100%	0%	14,42
	V J 74	0%	0%	0%	0%	0
	LCY 75	03	0%	100%	0%	12
	0110					1.0





#### Desirability: Clinicians

- "I like the way the product looks and feels"
- Experts WIISEL Surveys: Interest



5 8 5 Clinician expert in gait and posture assessment Expert in wearable technologies Researcher in the field of fall detection-prevention Researcher in the field of gait and posture analisys Other

#### Desirability: Experts

• Experts' WIISEL Surveys: Details

Desired Characteristic	Frequency
In real life settings	22
Constant monitoring	13
Through wearable and unobtrusive device	12
Long term monitoring	15 11 25
Measurement of multiple parameters	9
Facility to include new functionalities	4
Other: Variability	N23 1

# Conclusions

#### What WIISEL have achieved

- WIISEL system is useful for studying fall risk and as a clinical tool for long-term monitoring in the home and community settings, saving time and cost
- Wireless insoles are easier to use than wired insoles
- User's acceptance is encouraging
- Flexible SW platform adaptable to any users' group
- New Fall Risk Index captures fall risk similar that conventional performance-based tests like the Tinetti gait and balance test and the Dynamic Gait Index.

#### Facts

#### 657 hours collecting data

- 15 subjects tested during pilot
- 39 subjects tested during validation studies
- 16 experts tested the usability/ergonomics
- 180 insoles manufactured (different phases)
  - 22 Smartphones (Nexus 4)
  - 15 Battery extenders
  - 35 Inductive Chargers & adapters

#### **Current cost of WIISEL pair of insoles ~ 800€**

Scientists and researchers experts in gait, posture and movement analysis, fall prevention and intervention

#### **On-going Development**

- Update the insole platform to decrease cost and increase reliability to address a wider market
  - Use new wireless protocols for data transfer and charging
- Validate the system on a wider population set
- Develop and validate a service model
- Move from TRL5-6 to TRL9-10

 Specific applications in ageing, geriatric deontology, clinicians (geriatricians, neurologists), specialists in orthopaedics, allied health professionals, care providers, rehabilitation & clinical care, research for insurances

 Non-clinical context: researchers & scientists in sports, arts performers, military, high-risk workers, wearable ehealth devices, smart homes, etc.

# Moltes gràcies per la vostra atenciò