Todas las imágenes/fotografías contenidas en esta presentación se han referenciado a sus respectivos autores o son de elaboración propia

A Neural Network for Stance Phase detection in smart cane users

J.R Caro-Romero, J. Ballesteros, F. Garcia-Lagos,

C. Urdiales and F. Sandoval

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HOW TO ASSESS CONDITION IN PEOPLE?

@brandalley.fr

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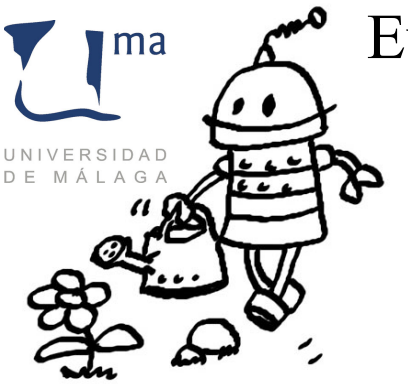
HOW TO ASSESS CONDITION IN PEOPLE WITH DISABILITIES?

GAIT ASSESSMENT

Gold standard method
Non-invasive
Multiple measurements can be recorded simultaneously
Information on functional abilities
Guide rehabilitative and treatment plans
Improve functional outcome following a treatment
Feedback to patients on progress
Evidence of its benefits



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GAIT ASSESSMENT

- Vestibular disorder
- Parkinson
- Amputees
- Neurologic rehabilitation
- Spinal Cord Injury
- Stroke disorder
- Fall estimation

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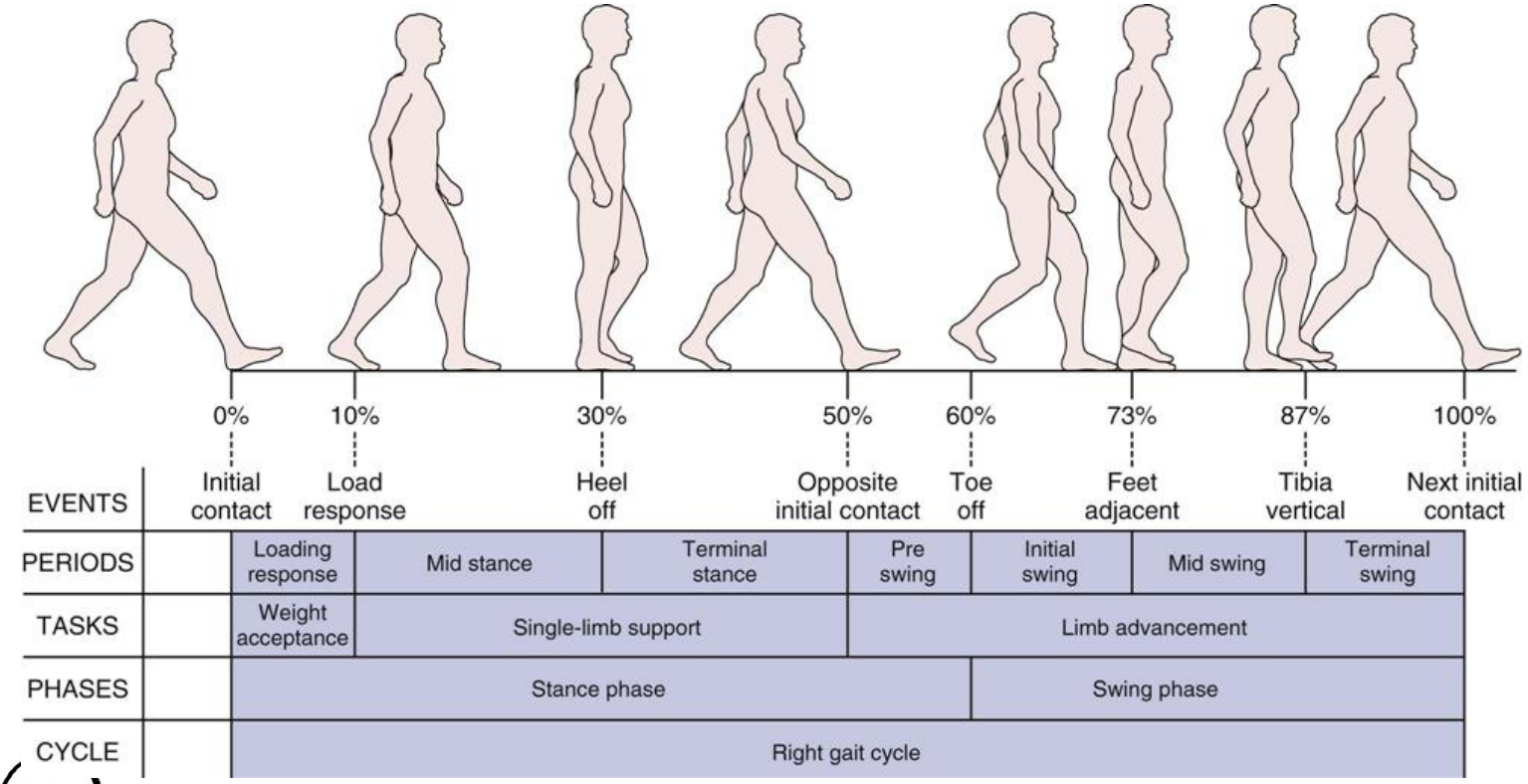
GAIT ASSESSMENT



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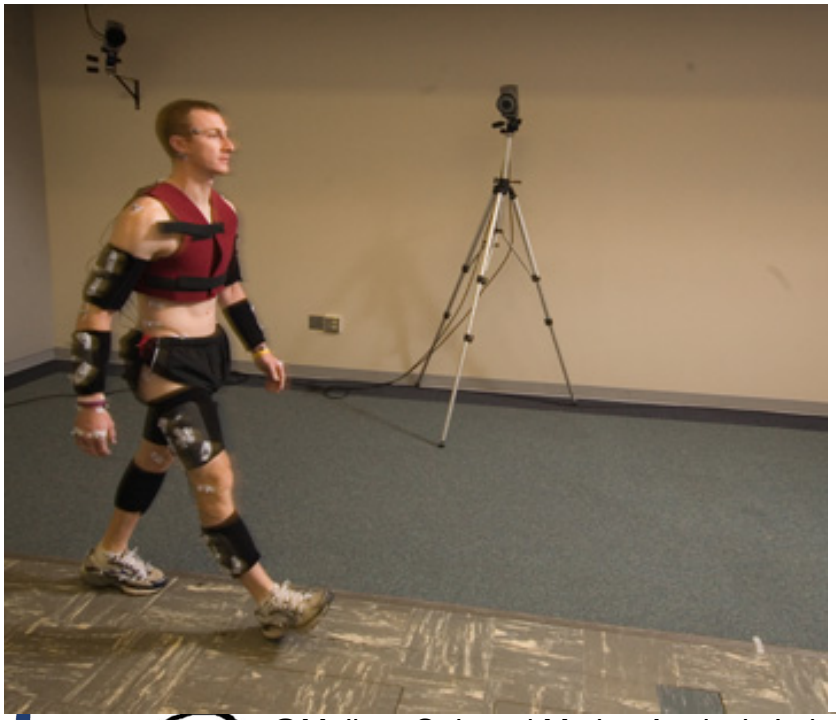
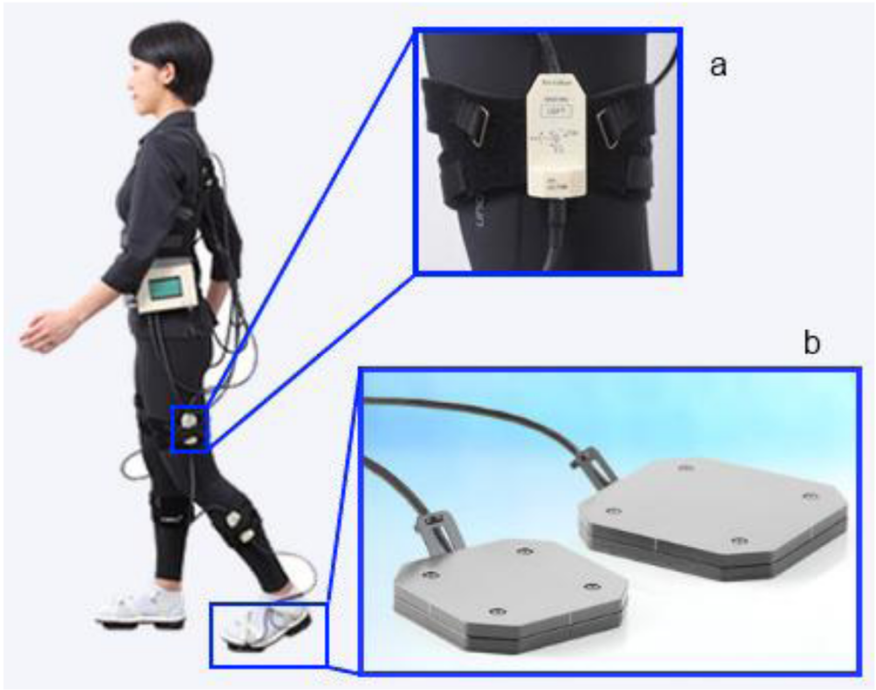
GAIT ASSESSMENT



@Maikos-Gait and Motion Analysis Lab



@MOVE-IT - EIT Health

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GAIT ASSESSMENT

@CSM 2017: San Antonio, Texas

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MOBILITY ASSISTIVE DEVICES

@walkagain.com

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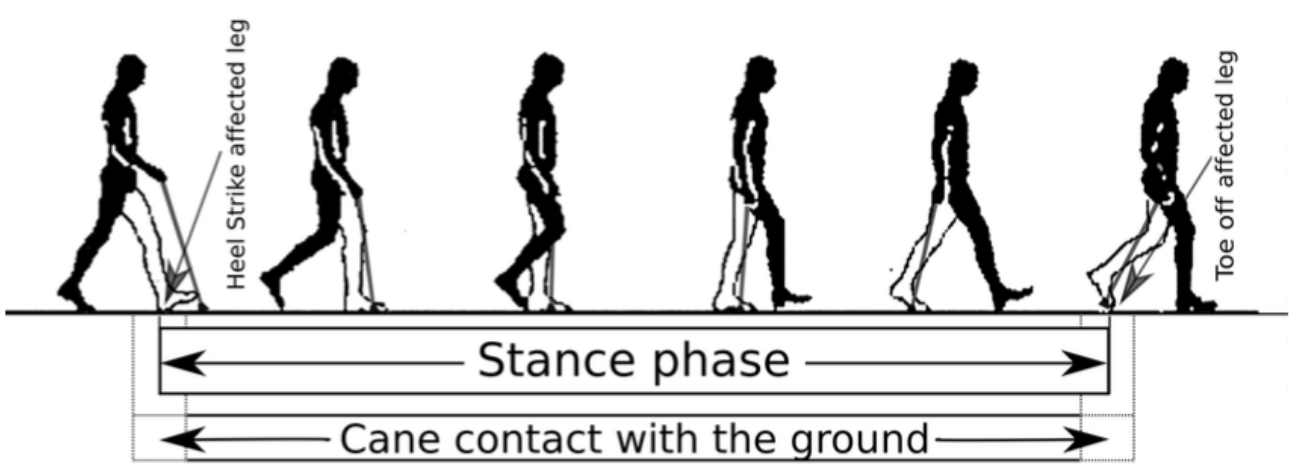
GAIT CYCLE
(AFFECTED STANCE PHASE)



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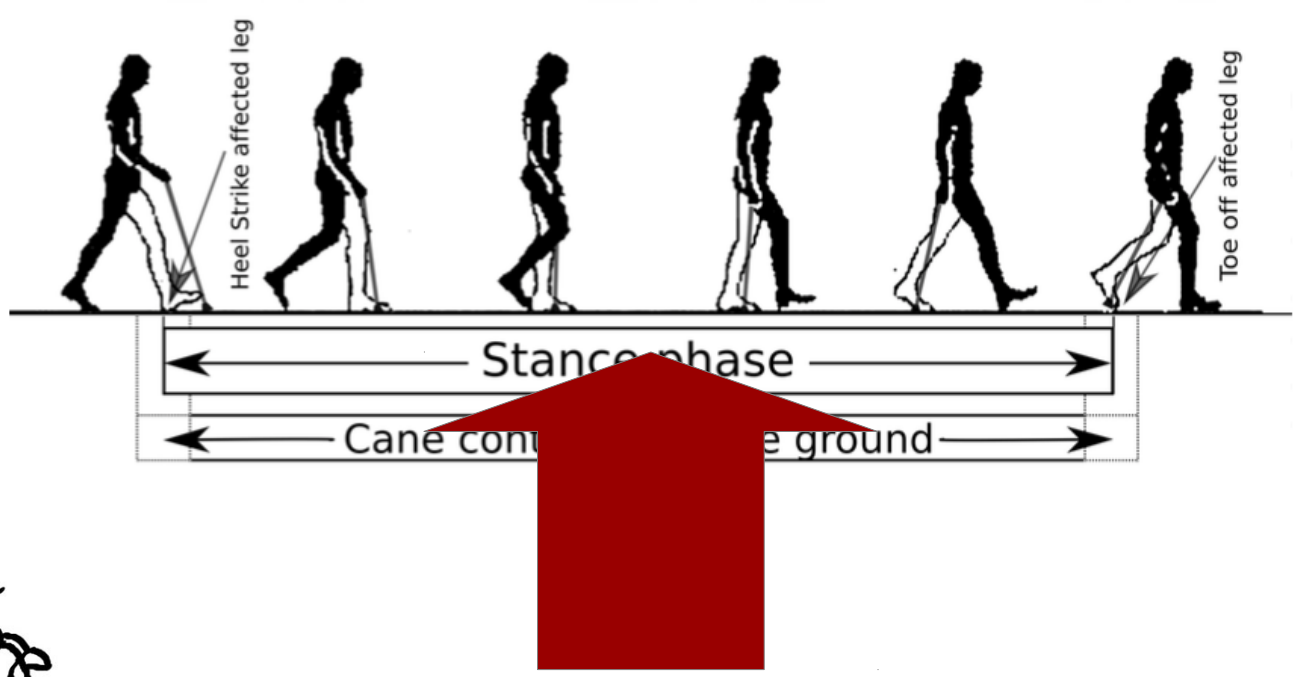
GAIT CYCLE
(AFFECTED STANCE PHASE)



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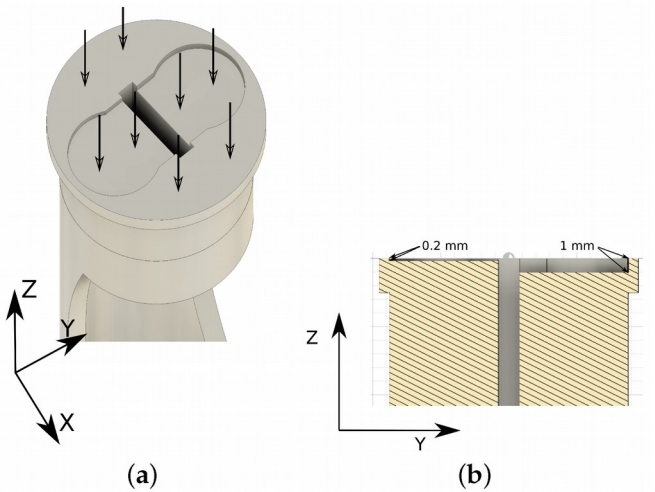
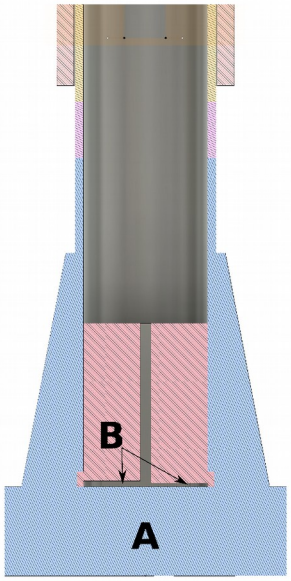
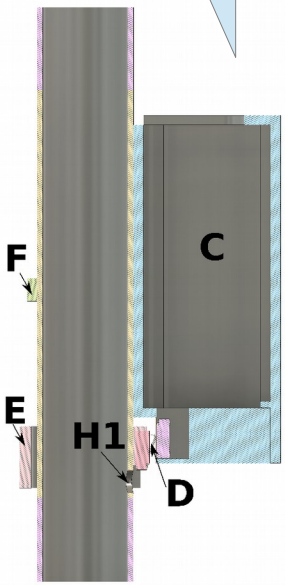
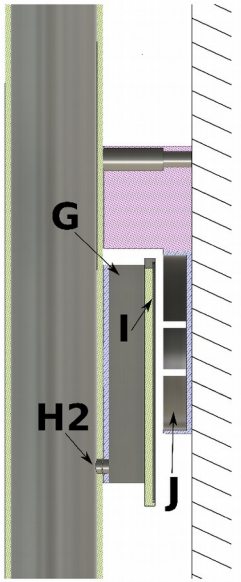
MEASURING GAIT WITH A CANE



INCREASE SENSOR RANGE







(a) General View (b) Sensors Area (c) MCU area (d) Charger area

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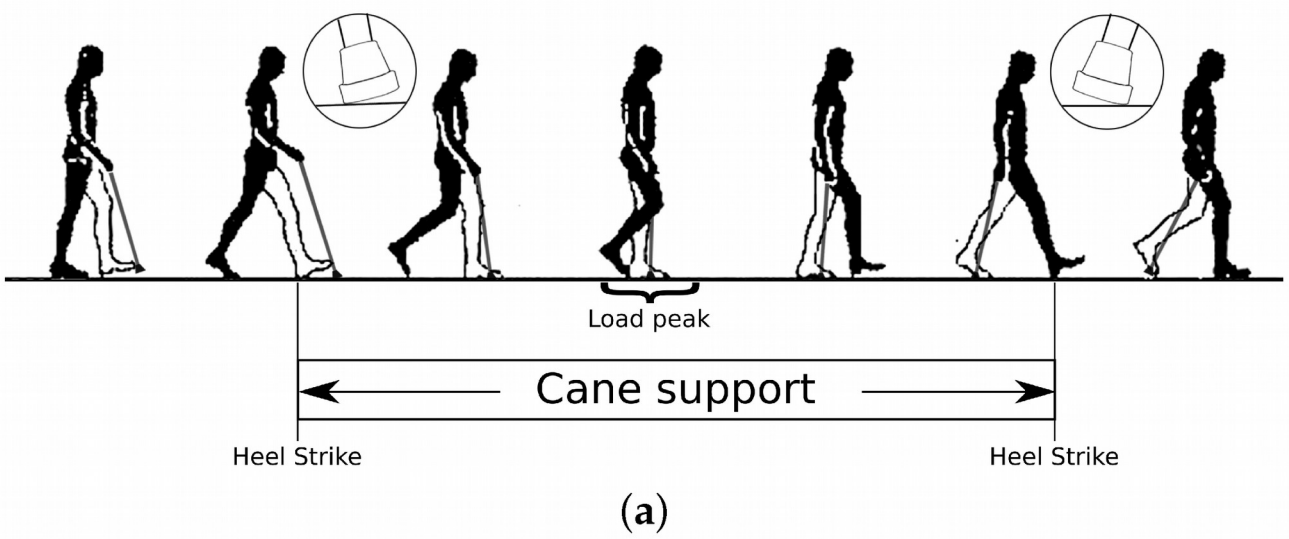
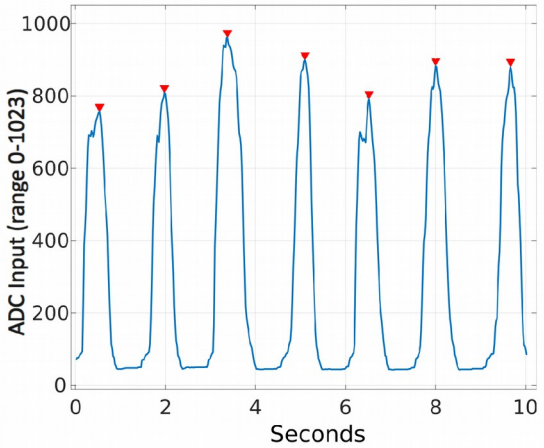
MEASURING GAIT WITH A CANE



(a)



(b)

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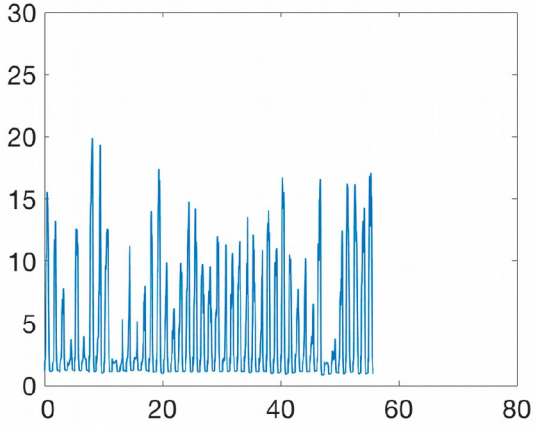
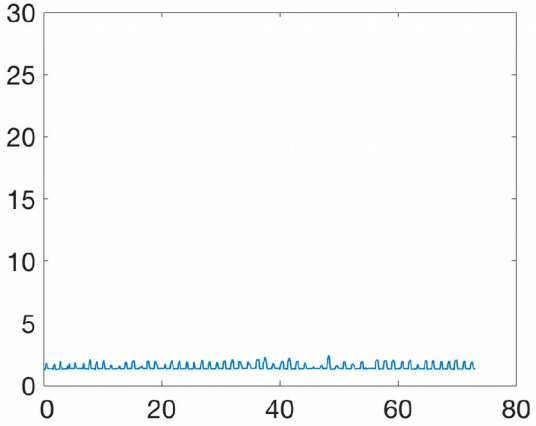
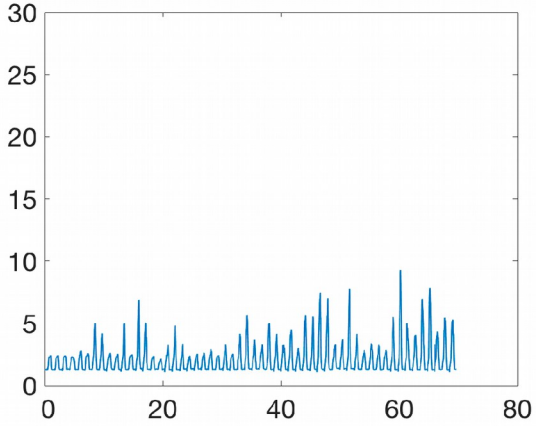
ISSUES WITH THRESHOLDING



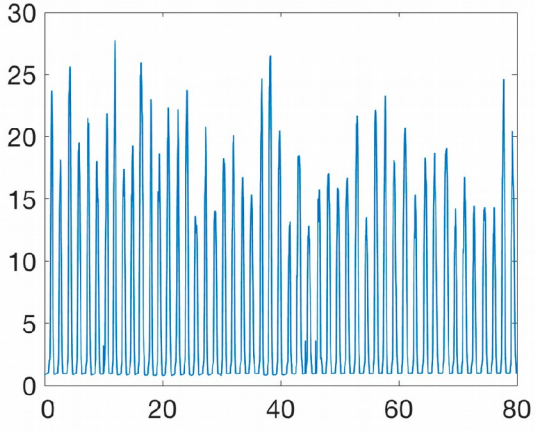
(a) User 1



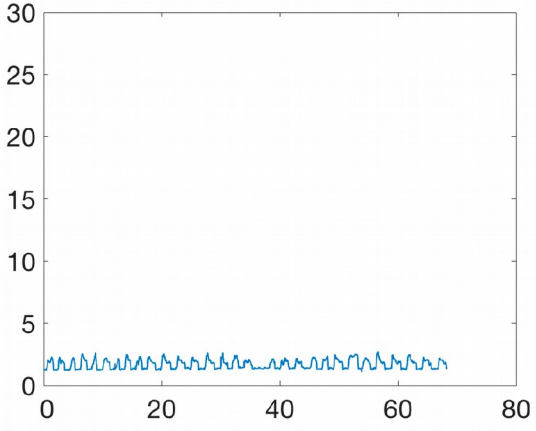
(b) User 2



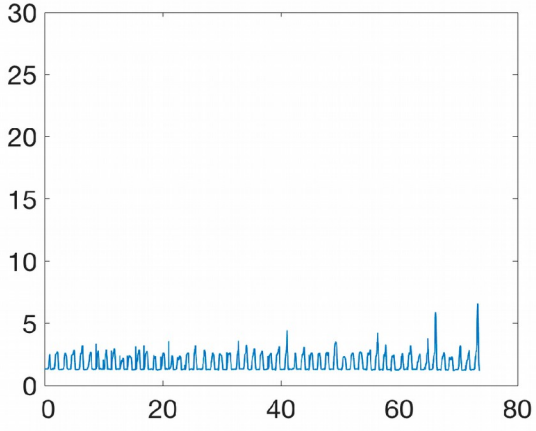
(c) User 3



(d) User 4



(e) User 5

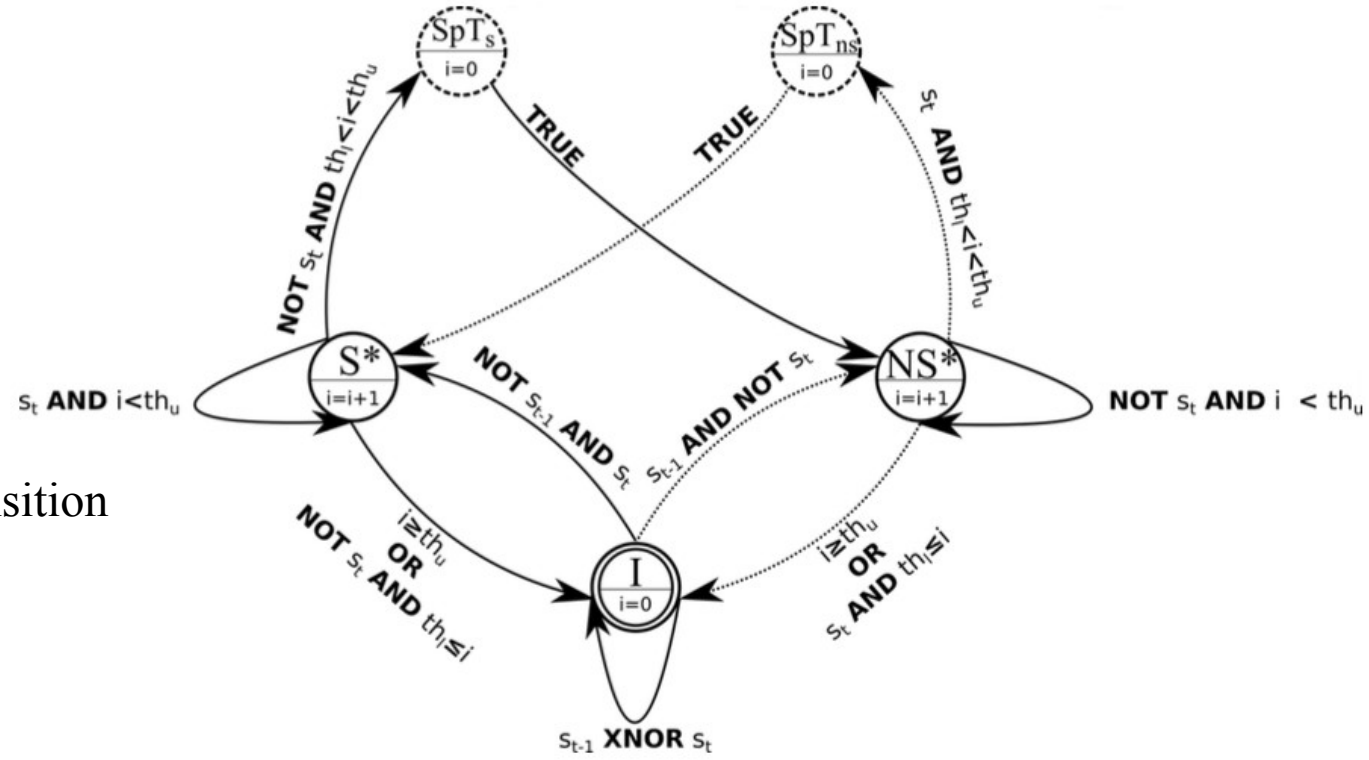


(f) User 6

POTENTIAL SOLUTIONS

States are:

I: Idle
S*: Support
NS*: Non Support
SpTns: Support Transition to NS*
SpTs: Support Transition to S*



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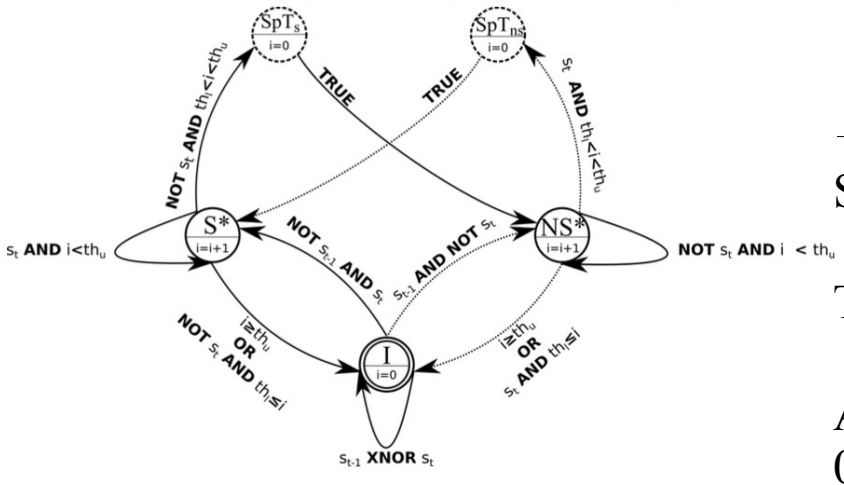
POTENTIAL SOLUTIONS



Best solution meeting performance criteria (accuracy, sensitivity and specificity).

Sensor Threshold to determine activity: S_{th}= 15s

Time Threshold to revert to Idle state:

Average cane support time (elderly cane users)
0.77±0.09s (male)
0.67±0.08s (female)

(for normal distribution)
th_l= 0.51s / th_h= 0.95s (95% population)

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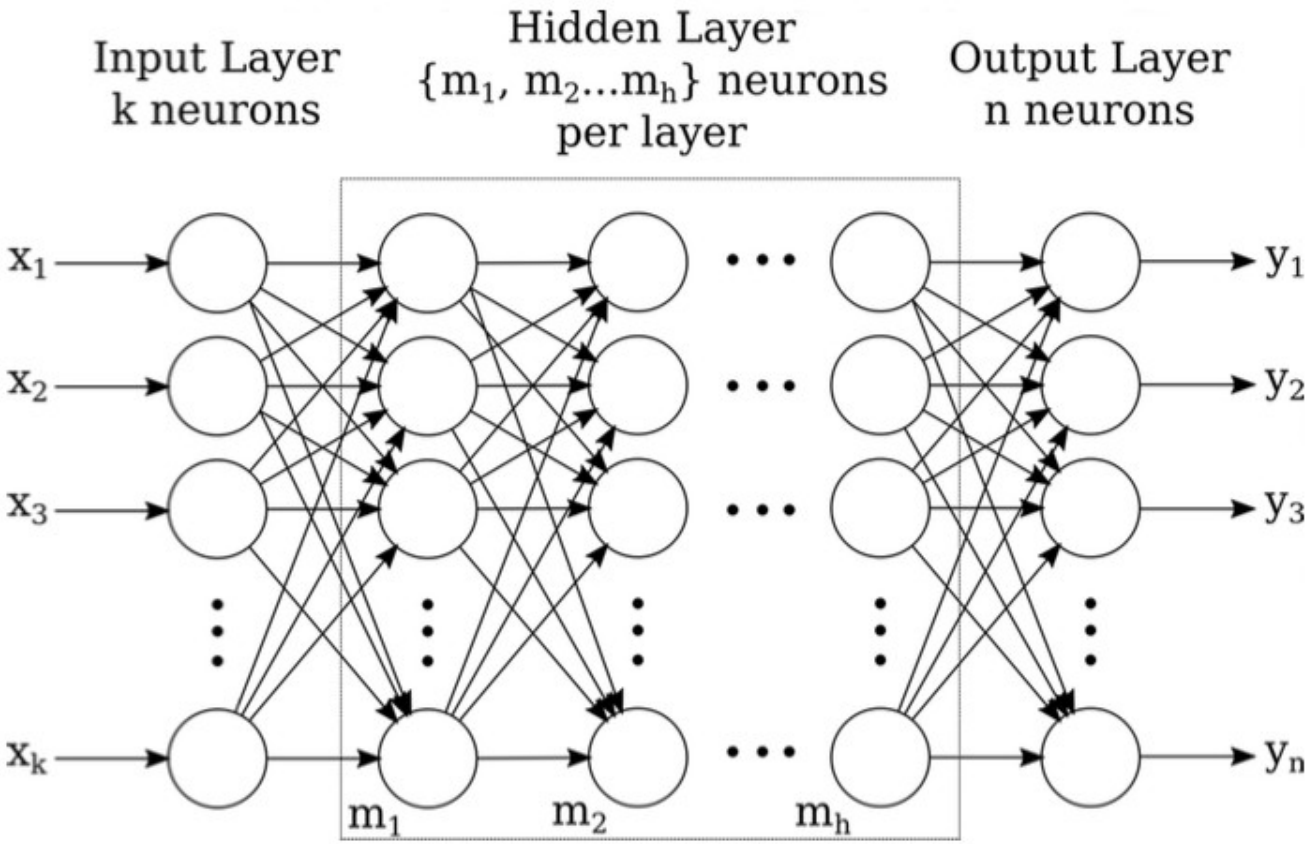
POTENTIAL SOLUTIONS



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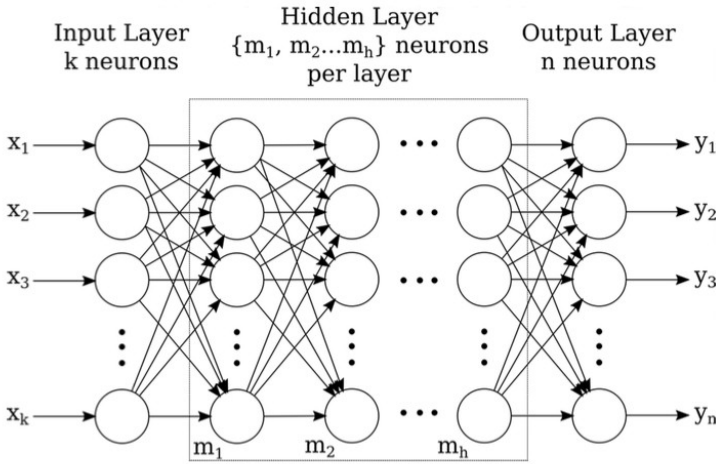
POTENTIAL SOLUTIONS



Least computationally expensive NN meeting performance criteria (accuracy, sensitivity and specificity).

Training: Levenberg-Marquardt BackpropagationNumber of Hidden Layers: 1
Activ. Func. Hidden Layer: Sigmoid and Softmax

Table 1. Condition and characteristics per users

Id	Age	Gender	Gait Speed	Physical Issues
1	80	M	0.615 m/s	Visual impairment; osteoarthritis; low back pain
2	87	M	0.498 m/s	Osteoarthritis (left knee)
3	86	M	0.687 m/s	Heart surgery; Lower limbs weakness
4	91	M	0.597 m/s	Vestibular disorder
5	74	M	0.792 m/s	Right knee prosthesis

Benchmarking: 200 FPS video camera

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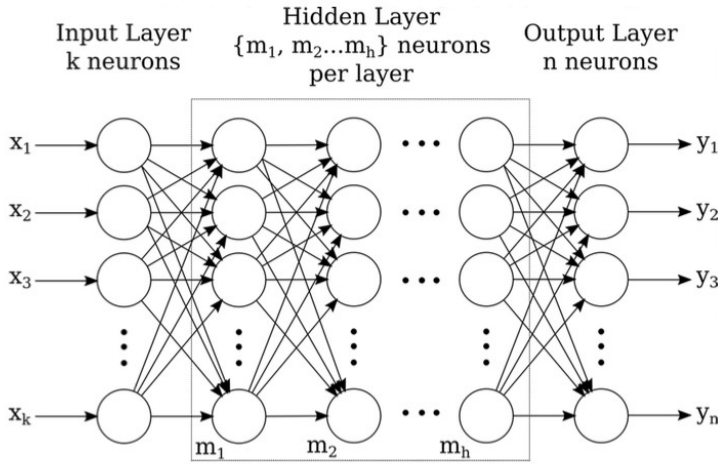
POTENTIAL SOLUTIONS



Least computationally expensive NN meeting performance criteria (accuracy, sensitivity and specificity).

(5-fold validation)

17 neurons in hidden layer

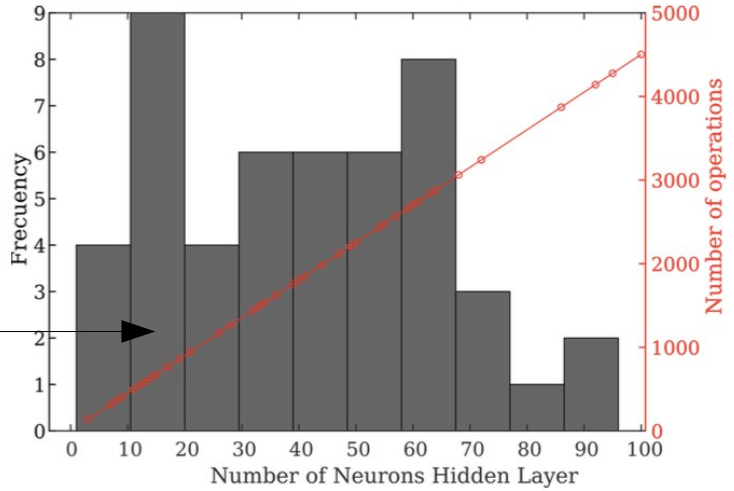


Fig. 4. Best MLP structures out of 50 tests

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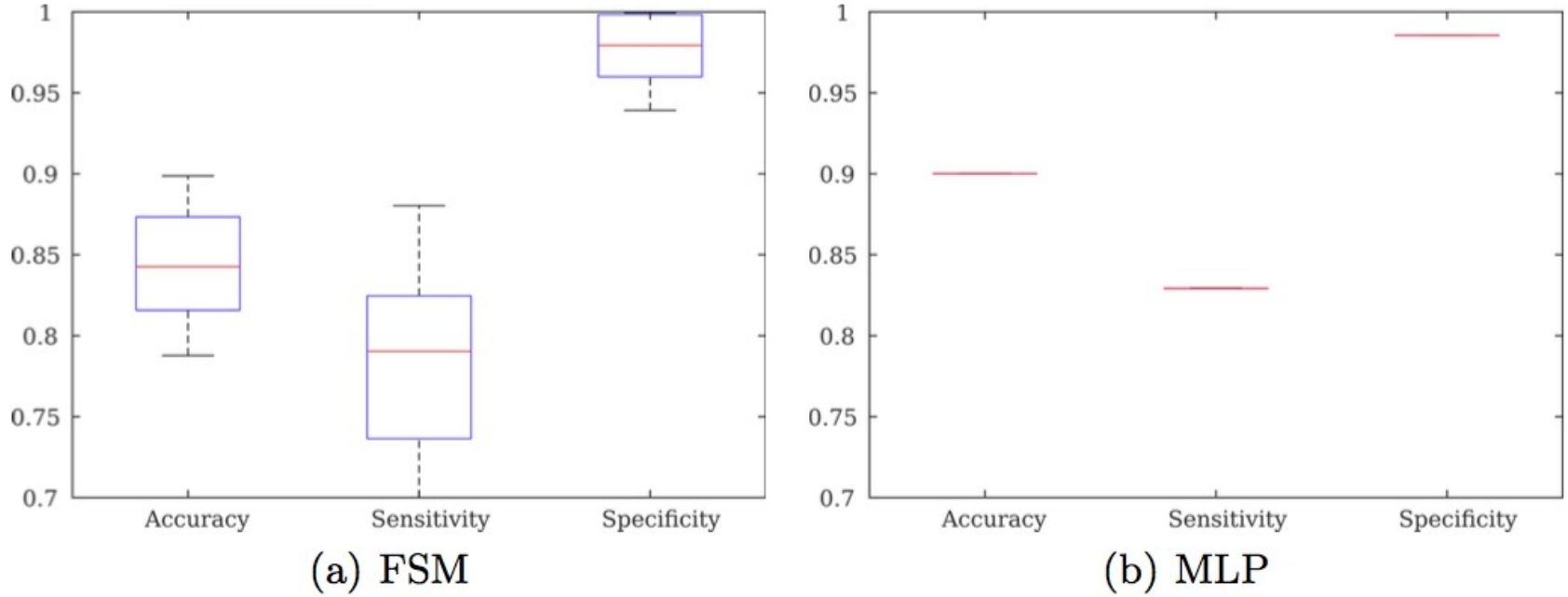
RESULTS: FSM VS MLP



(a) FSM

(b) MLP

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RESULTS: FSM VS MLP

		Volunteers					
		1	2	3	4	5	Average
FSM	Accuracy	0.8987	0.8649	0.7878	0.8251	0.8426	0.8438
	Specificity	0.9392	0.9994	0.9668	0.998	0.9793	0.9766
	Sensitivity	0.8804	0.8061	0.6948	0.7503	0.7903	0.7844
MLP	Accuracy	0.9583	0.8802	0.8762	0.8996	0.8861	0.9001
	Specificity	0.9996	0.9922	0.9596	0.9776	0.9986	0.9855
	Sensitivity	0.9004	0.7921	0.8263	0.8385	0.7888	0.8292

RESULTS: FSM VS MLP

TRUE NEGATIVE RATE

		Volunteers					
		1	2	3	4	5	Average
FSM	Accuracy	0.8987	0.8649	0.7878	0.8251	0.8426	0.8438
	Specificity	0.9392	0.9994	0.9668	0.998	0.9793	0.9766
	Sensitivity	0.8804	0.8061	0.6948	0.7503	0.7903	0.7844
MLP	Accuracy	0.9583	0.8802	0.8762	0.8996	0.8861	0.9001
	Specificity	0.9996	0.9922	0.9596	0.9776	0.9986	0.9855
	Sensitivity	0.9004	0.7921	0.8263	0.8385	0.7888	0.8292

Worse condition
(in terms of gait speed)

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CONCLUSIONS AND FUTURE WORK

- Thresholding for support based gait assessment is not valid for users with **high assymmetries** not those who **support little weight** on the cane
- MLP (1 input neuron, 10-20 neurons in hidden layer and 1 output neuron) achieve **90% accuracy using less than 800 operations**.
- **MLP adapts better to persons' condition**, i.e. results present lower variance
- Only 5 volunteers were tested. **Further tests** are needed to confirm results and, then, extract more gait parameters.

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THANK YOU FOR YOUR ATTENTION

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