Gait analysis for challenged users based on a rollator equipped with force sensors

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INTRODUCTION

Gait analysis

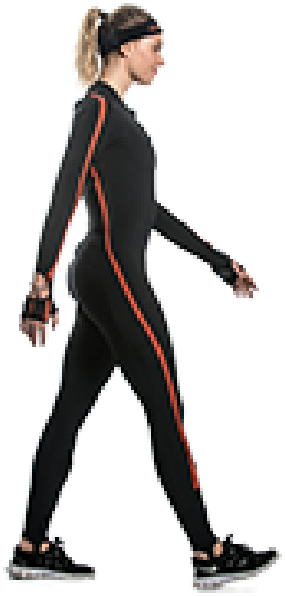
- Neuropathology: Step time (Left vs Right) or step length (Left vs Right)
- Orthopaedic lower limbs: Weight-bearing
- Elderly: Cadence, walking velocity,...

How disability affect to some gait parameters

Gait	Division	Gait Parameters						
		CAD	SdT	SdL	SpT	SpL	WV	WB
Healthy [12]	Men Women	102(8) 113(20)	1.18(0.08) 1.06(0.13)	1.39(0.014) 1.23(0.17)	0.59(0.05) 0.53(0.06)	0.69(0.08) 0.61(0.09)	1.17(0.16) 1.16(0.2)	– –
Antalgic	affected non affected				↓ [18] - [18]	↓ [18] - [18]		↓ [19]
Ataxic	-	↓ [20]	∨ [21]	↓ [21]	↑ ∨ [21]	↓ [21]	↓ [21]	
Hypokinetic		- [22]		↓ [23]		↓ ∨ [21]	↓ [21]	
Vestibular		↑ [24]	↓ [24]				↓ [25]	
Spastic		↓ [26]					↓ [26]	
Paretic	affected Non affected	↓ [27]	↑ [27]	↓ [27]	↓ [28] - [28]	↓ [27]	↓ [27]	↓ [28]
Cautious [29]	-			↓		↓	↓	
Dyskinetic	Involuntary movements or postures, these abnormalities can not be measured consistently.							

Specific tools

GAITRite System



MVN BIOMECH Awinda

Optotrak Certus

Force sensors on i-Walker

- 3 force components in handlebar
- Encoders in both wheels
- Tilt sensor and 2 forces sensor for normal force
- 2D laser

Force sensors on a rollator

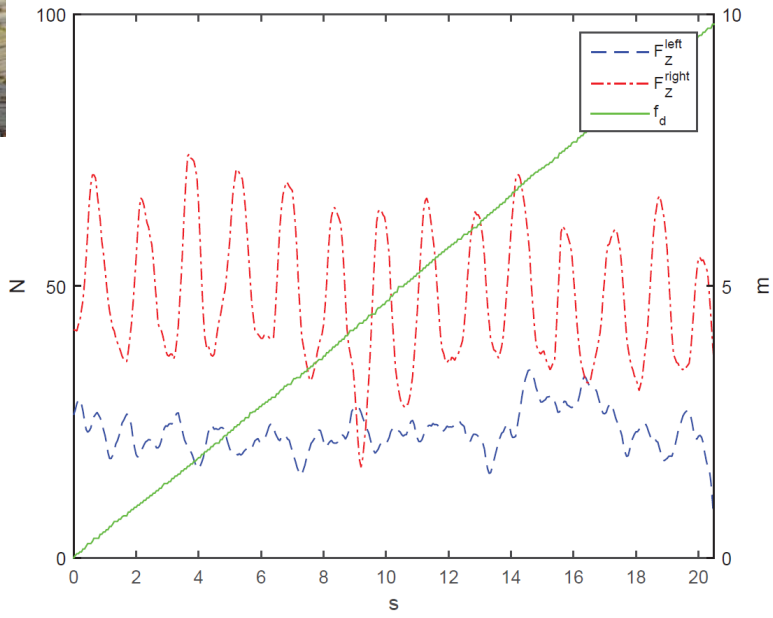
- Disadvantages:
  - Low accuracy
  - It can not measures gait kinematic, only spatiotemporal gait parameters.

- Advantages:
  - Assistive device for rehabilitation process.
  - Minimal configuration changes.
  - Can be used in everyday conditions and for a long term monitoring.

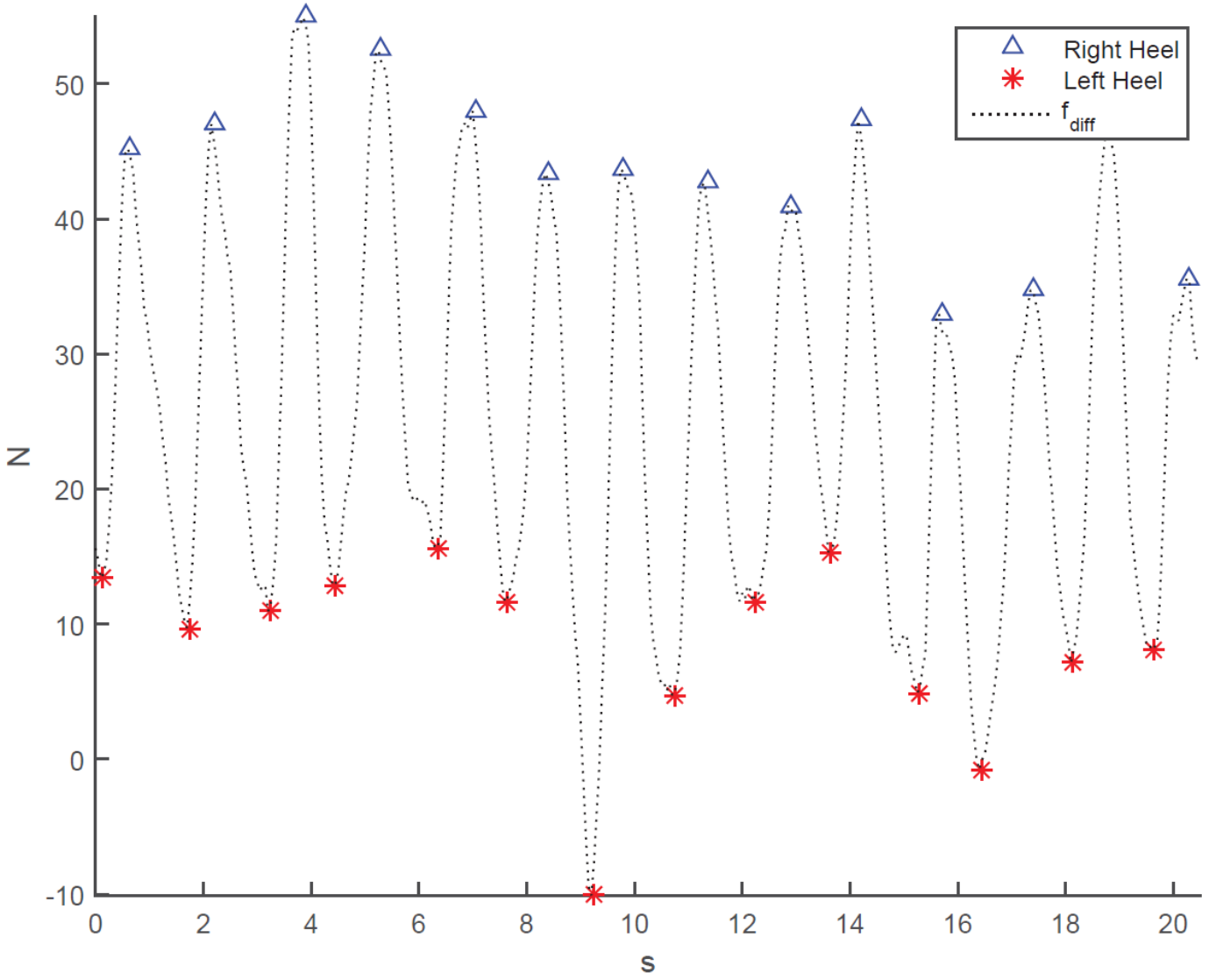
METHODOLOGY

When users initiates heel contact…

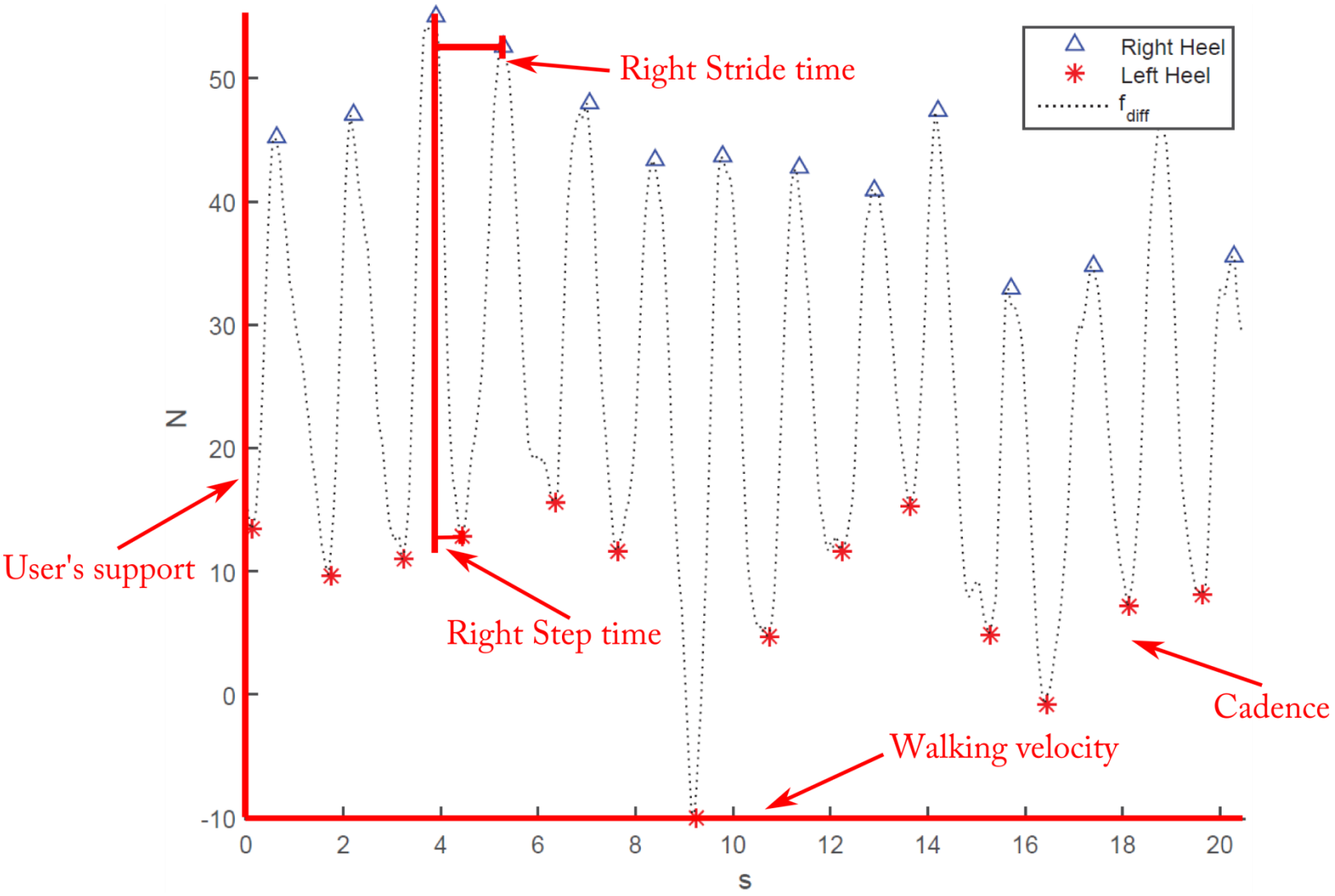
Input sensors for user 8



Peaks in difference between forces

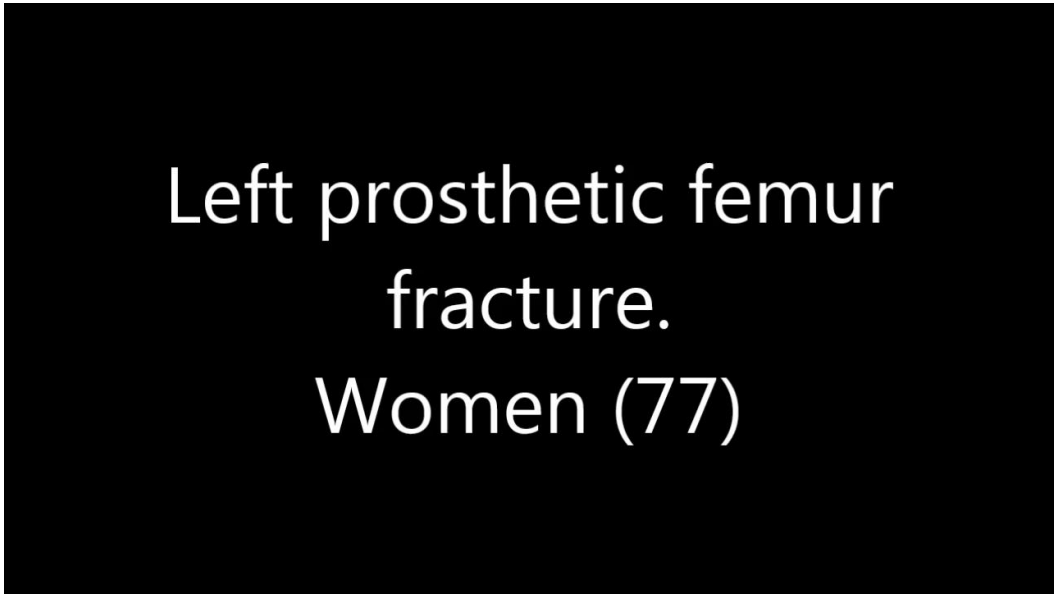


Estimation of gait parameters

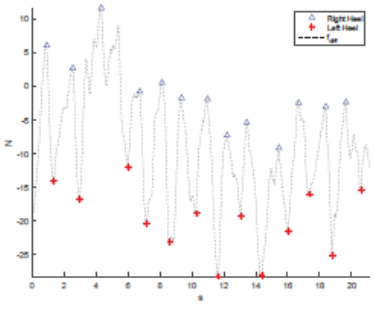


Testing our algorithm

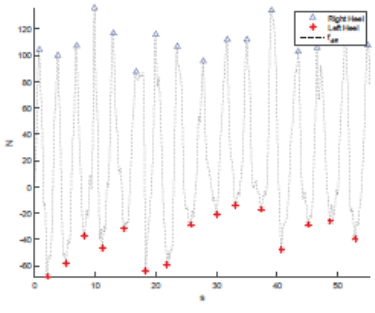
- 9 volunteers: 6 women and 3 men
- They had a variety of cognitive and/or physical disabilities
- Users are in average 68 years old (range 45-86 years)
- 10 meter test



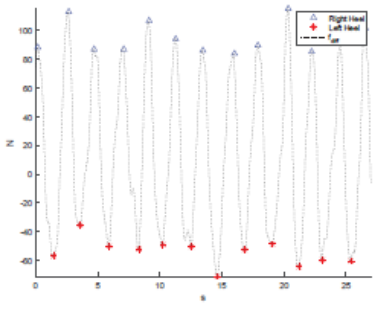
Result



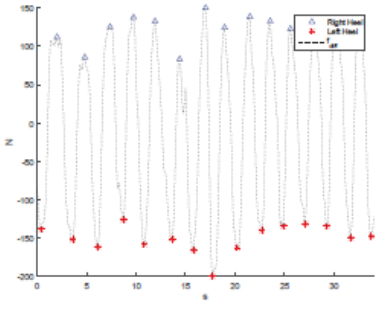
(a) User 1



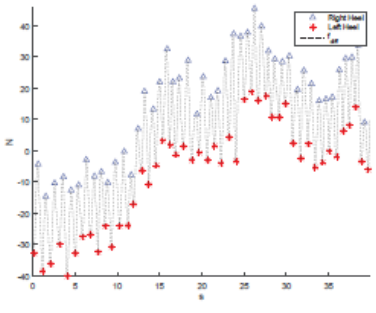
(b) User 2



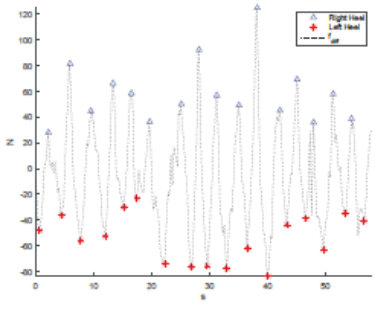
(c) User 3



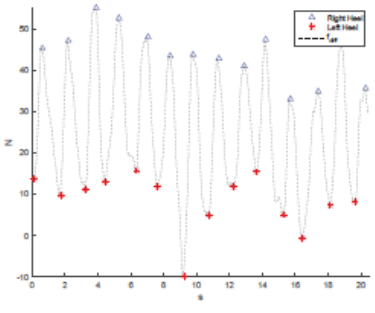
(d) User 4



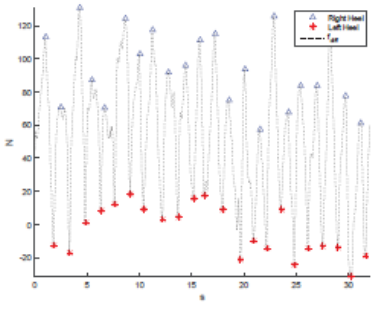
(e) User 5



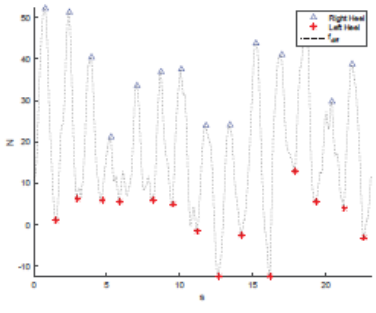
(f) User 6



(g) User 7



(h) User 8



(i) User 9

Results validated by medical staff

User	Leg	CAD	SdT	SdL	SpT	SpL	WV	UrS
1	Left Right	73.9336	1.5813(0.4308)	0.7649(0.2002)	0.8458(0.2896) 0.7308(0.3655)	0.4302(0.1412) 0.3296(0.171)	0.4829	56.5301(7.0931) 55.4994(7.8742)
2	Left Right	33.6347	3.619(0.5296)	0.6473(0.1369)	1.8733(0.3698) 1.74(0.3781)	0.3183(0.1328) 0.329(0.0522)	0.1801	141.7732(50.2771) 138.5881(58.2236)
3	Left Right	55.5556	2.187(0.1967)	0.7089(0.0618)	1.125(0.0541) 1.0708(0.184)	0.3339(0.0541) 0.3806(0.0546)	0.3248	107.3875(32.7621) 112.432(28.6415)
4	Left Right	51.1013	2.3741(0.2923)	0.6933(0.0459)	1.0821(0.2366) 1.3036(0.2341)	0.3208(0.0465) 0.3731(0.0482)	0.2899	184.1019(39.8449) 193.2380(32.2076)
5	Left Right	142.5532	0.8408(0.0956)	0.2039(0.0253)	0.4076(0.0911) 0.4348(0.0701)	0.1029(0.0222) 0.102(0.0221)	0.2423	129.4412(10.126) 124.7827(10.1273)
6	Left Right	34.1969	3.4935(0.6364)	0.6256(0.1848)	1.6813(0.4557) 1.8156(0.4456)	0.376(0.1817) 0.2465(0.043)	0.1782	181.2906(56.7767) 122.3216(44.4457)
7	Left Right	81.95	1.5058(0.1728)	0.72(0.0791)	0.6357(0.1486) 0.8654(0.1819)	0.3150(0.0721) 0.4018(0.0786)	0.4788	73.0059(11.5508) 70.9994(12.8941)
8	Left Right	82.3713	1.4262(0.192)	0.2242(0.0468)	0.7143(0.1898) 0.7091(0.1931)	0.1124(0.0331) 0.1103(0.0356)	0.1544	217.7974(50.0625) 228.4787(70.0204)
9	Left Right	72.7273	1.6192(0.2324)	0.5846(0.0931)	0.7932(0.2231) 0.8214(0.1578)	0.2845(0.0853) 0.3005(0.0676)	0.3626	59.062(7.8287) 57.6729(8.3495)

CONCLUSION AND FUTURE WORK

Conclusions

- It has been validated with a number of volunteers presenting a variety of disabilities.
- The gait parameters evolve according to reported clinical studies and is coherent with the reported users' diagnosis

- Unlike more complex methods, it does not provide enough information for detailed gait analysis (e.g. kinematic analysis of joint rotations).
- It requires the user to lean on both handlebars

Future work

- Normalization of the obtained data
- To increase the number of volunteers (currently we have 25)
- To reduce the margin of error in heel contact detection

The end

Thank you for your attention