



Minimum acceleration criterion with constraints as a tool to detect the onset time and initial motor command of reaching movements

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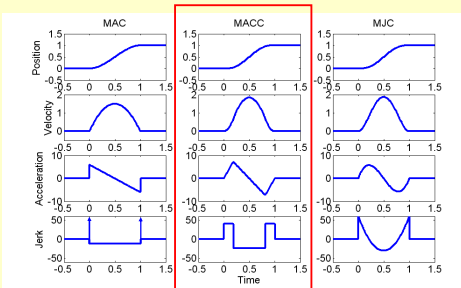


INTRODUCTION

- The onset time and the initial velocity profile of reaching movements provide valuable information about the feedforward neural command
- Velocity threshold techniques are typically used in such analyses
- We propose an alternative, simple reliable and much more accurate, onset detection method based on the predicted trajectory of the minimum acceleration criterion with constraints. Ben-Itzhak and Karniel, *Neural Computation*, 20(3):779-812, 2008

METHODS

1 Minimum Acceleration Criterion with Constraints BI&K (2008)



$$\ddot{x} = \begin{cases} u_m & 0 \leq t \leq t_1 \\ c_0 & t_1 \leq t \leq t_2 \\ u_m & t_2 \leq t \leq 1 \end{cases} \quad t_{1,2} = \frac{1}{2} \pm \frac{1}{2} \sqrt{\frac{u_m - 24}{u_m}}$$

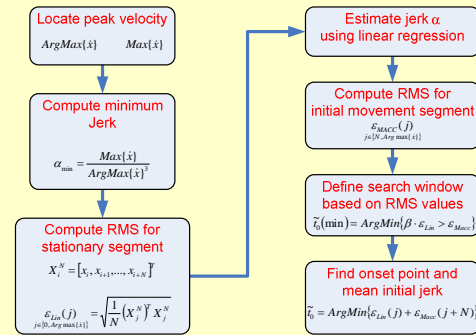
$$c_0 = \frac{-24u_m}{u_m - 24 + \sqrt{u_m(u_m - 24)}}$$

- According to MACC, in the first part of the movement the trajectory takes the following simple form:

$$x(t) = \alpha t^3$$

2 The Algorithm

[Onset, α] = MACCINIT(X)
maccinit.m is available at
http://www.bgu.ac.il/~akarniel/pub_list.html



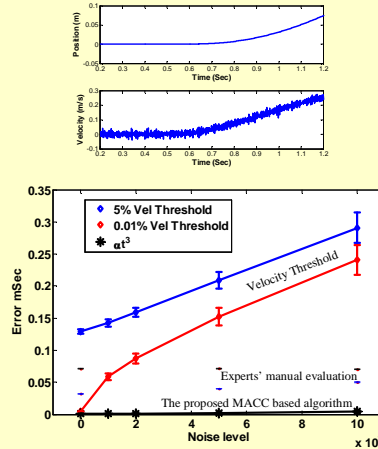
- Based on the MACC we wrote a simple code to extract the onset time of a movement and the average jerk at the beginning of the movement
- We tested this algorithm on a set of simulated trajectories based on a noisy minimum jerk profile
- We also asked two experienced researchers to manually mark the onset of each movement observing the position and velocity profiles

RESULTS

- Figure 3 demonstrates the clear superiority of the proposed method
- In a case study of lifting task with control subjects and with a teenager with Cerebral Palsy we extracted the average jerk during the first 100ms of the movement, namely the motor command.
- The results of this study clearly indicating lack of predictive control in the CP subject compared to the control subject (Figure 4).

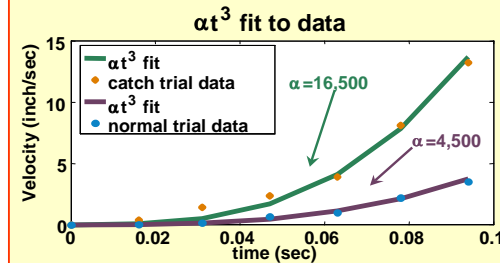
3 Simulation results

Reaching movements database using minimum jerk trajectories and normal additive noise was generated. The onset time was extracted using conventional velocity threshold method and the proposed method.



4 Experimental results

The motor task was to grip and lift the object up to a marked point 55cm above the table. In regular trials subjects performed the motor task with an object of 155g. In catch trials the object weight was 45g



DISCUSSION

- The proposed method use more data points and therefore is more accurate than simple threshold methods which are sensitive to noise at the specific sampling point
- The method is insensitive to the validity of the MACC scientific hypothesis. The only assumption is similarity of the initial trajectory to t^3
- The observation that the average jerk at the beginning of the movement was the best measure of the predictive nature in the grip and lift task is in concert with recent studies observing the grip and load force rates (e.g., Raghavan et al. *Brain* 2006)

ACKNOWLEDGEMENTS

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