Center-out Paradigm For a Continuous Two-Dimensional BCI Control

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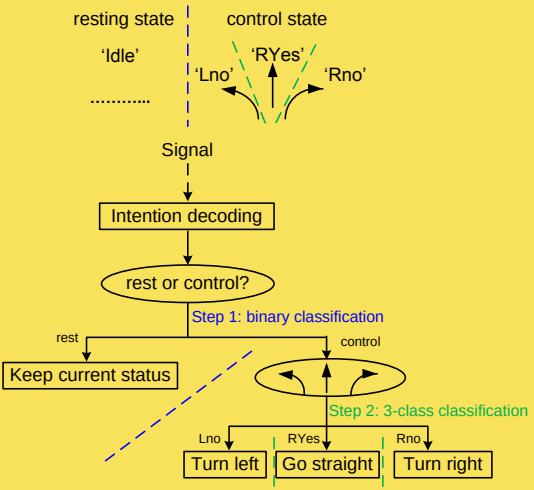
OBJECTIVES

- Investigate the online performance of the BCI, using a 2D center-out car control paradigm
- Reliable decoding of human movement intention from EEG activities using two-step models, without intensive user training
- Towards the development of a reliable wheelchair control with decent speed

METHODS

❖ Design follows the rules: control should be natural & user friendly; avoid false triggering; no intensive user training.



• Idle: no motor task.
RYes: imagine right hand movement for 4s, then relax
Rno: imagine right hand movement for 1.5s, then relax
Lno: imagine left hand movement for 1.5s, then relax

• two-step models are built using calibration data, half of which are idle, half are evenly divided by RYes, Rno, and Lno.

CONTROL STRATEGY

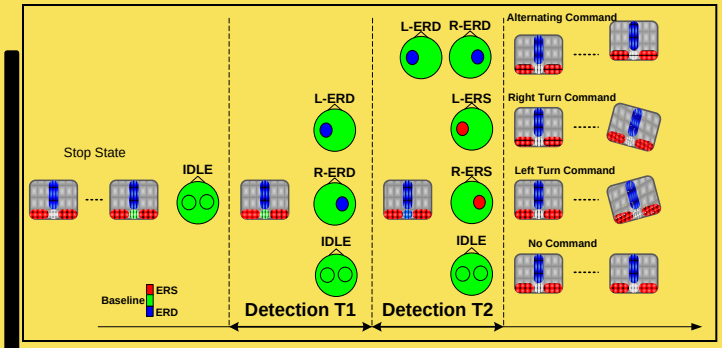
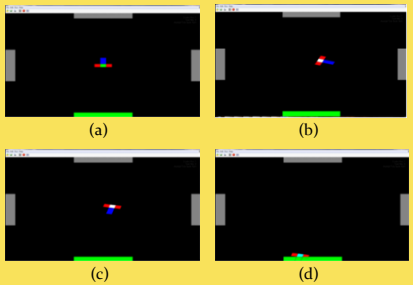


Figure: Time sequence of the control strategy

Detection T1	Detection T2	Output Commands
Left ERD	Left ERS	**Right Turn**
Right ERD	Right ERS	**Left Turn**
Left (Right) ERD	Left (Right) ERD	**Alternating**
Left (Right) Idle	Left (Right) Idle	**Keep status**

EXPERIMENTAL PARADIGM



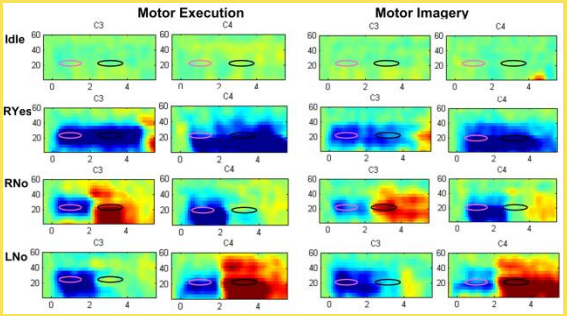
(a)-(b) Perform RNo task once, rotate the car; then Idle keeps car rotating.
(c) Perform RYes task, change status from right turn to go forward.
(d) Car hit the target.

Note: status changing, **predict in advance!**

Parameter settings:
• target size (6)/workspace size (100)=1.5/100
• car rotating speed=2*pi/27 (rad/s)
• car moving speed=0.4 (m/s)
• decision making cycle=1.5+2.5+2=6 (s)

Movement should pace with the color cues or audio cues

RESULT



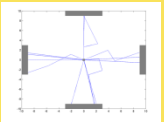
Car control		Taken as				total	Acc
physical		Idle	RYes	Rno	Lno		
Idle		63	0	2	0	65	96.90%
Non-idle	RYes	0	22	1	0	23	95.70%
	Rno	1	0	10	0	11	90.90%
	Lno	0	0	0	8	8	100%

❑ 20 times hit rate 100%, total decoding Acc 96.3%
❑ average target hit time 32.1 second

Imaginary	Idle	RYes	Rno	Lno	Average
Decoding Acc	98.3	74.2	75.8	83.3	88.1

❑ offline average command decoding accuracy 88.1%
❑ 10 times hit rate 80%
❑ average target hit time 52 second

Trajectories of 16 runs for motor imagery



DISCUSSION

❖ pre-set proper FP & TP rates to guarantee binary classification accuracy. Idle & RYes are frequently used, require high accuracy when building model for online.
❖ when car rotation and forwarding speed both increase 20%, with decision making window shortened by 1 second, hit rate for physical test remains 100%
❖ decision making window length and car speed can be further optimized, especially for imaginary test.