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Swim Speed Monitoring Device for Rapid Feedback

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Introduction

Swimming stroke length, stroke rate and speed are the basic biomechanical parameters for training feedback. Video based motion analysis is a standard method in the area of sports biomechanics to determine these parameters. However, follow up procedure is needed to process the video footage and data. There is a limitation on the production of swimming data for the coaches and swimmers right after training. In 2003, Bideau developed an Active Drag Evaluation System (A.D.E.S.) which introduce a draw-wiring speed-time monitoring device for determining the resistive drag in swimmer. However, the system did not provide any solution on the determination of stroke cycle. In this study, a short first-in-first-out (FIFO) data queue was introduced to identify swimming stroke cycle. Therefore, swimming stroke length, stroke rate and speed could be rapidly determined and displayed to swimmer.

Methodology

Based on A.D.E.S. protocol, another cable tethering speed-time monitoring device was introduced (Figure 1). The swimmer was tethered with a non-elastic cable coming from the device mounted next to the start block. The cable was rolled on the axle of spool. A tailor made laser beam interrupt module was attached to the spool to detect the rolling speed, and the microsecond timing resolution of an Arduino UNO R3 board was used. Then the speed and time data were sent to the computer.

Figure 1. Cable tethering speed-time monitoring device setup

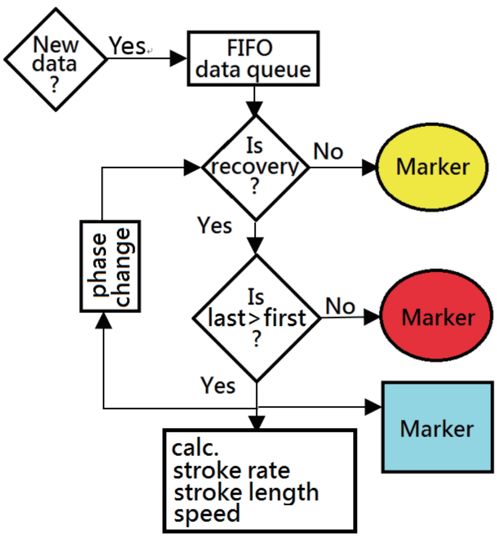

Figure 2. Logical flow chart of stroke cycles detection during recovery phase

An automatic swim cycle detection algorithm was implemented in the system. The algorithm is based on the phenomena in different swim phases: (1) decreasing swim speed in recovery phase and (2) increasing swim speed in propulsion phase. The principle behind on this algorithm is to make comparison in real-time between the last swim speed and the first swim speed in the queue to identify the change of phase or cycle (Figure 2). So that, a stroke-based speed-time profile could be deduced.

A Hong Kong elite breaststroke swimmer took part in the data validation test session between video based motion analysis and swim speed monitoring device. The swimmer was asked to perform 3 sets of different swimming strategies in a 25m swimming pool. A Sony HDR-CX550 camcorder of 50 fps was located at the spectator area shooting side view of swimmer. At least 3 consecutive strokes were taken during the course. The video footages were processed by Dartfish 7.0 motion analysis software to determine the stroke length, stroke rate and swim speed. At the same time, the swim speed monitoring device collected data via an Arduino UNO R3 board and then streamed to an Intel i5 1.8GHz CPU notebook computer. The length of the data queue was chosen as 28.

Results and Discussion

The swimming stroke rate, stroke length and speed from 2 different methods were presented in Table 1. The mean and maximum standard deviation of difference on stroke rate, stroke length and speed were 0.01±0.03 (/s), -0.02±0.06 (m) and 0.00±0.03 (m/s) respectively. Corresponding results generated from the swim speed monitoring device were found to be 4.23%, 2.91%, and 1.84% of difference compared with the video based motion analysis method.

Table 1. Data comparison of a breaststroke swimmer between video based motion analysis method and swim speed monitoring device

Set	Stroke Rate (/s)			Stroke Length (m)			Speed (m/s)		
	Device	Video	*Diff.*	Device	Video	*Diff.*	Device	Video	*Diff.*
1	0.59	0.61	*-0.02*	1.97	1.95	*0.02*	1.16	1.19	*-0.03*
	0.63	0.61	*0.02*	1.86	1.87	*-0.01*	1.17	1.14	*0.03*
	0.60	0.63	*-0.03*	1.91	1.82	*0.09*	1.15	1.15	*-0.01*
2	0.61	0.60	*0.01*	1.91	1.95	*-0.04*	1.17	1.17	*-0.01*
	0.67	0.63	*0.04*	1.81	1.89	*-0.08*	1.21	1.18	*0.03*
	0.65	0.62	*0.03*	1.81	1.85	*-0.04*	1.18	1.16	*0.02*
3	0.76	0.79	*-0.03*	1.70	1.66	*0.04*	1.29	1.32	*-0.03*
	0.80	0.76	*0.04*	1.59	1.71	*-0.12*	1.27	1.30	*-0.02*
	0.80	0.77	*0.03*	1.59	1.62	*-0.03*	1.27	1.25	*0.03*

Conclusion and Recommendation

In order to provide stroke rate, stroke length and swim speed for training feedback, a prototype of swim speed monitoring device was setup and a simple but effective data comparison algorithm was introduced. A low computation cost and high accuracy algorithm to detect the change of swimming stroke phase for rapid feedback was designed. However, the choice of data queue length was critical and required fine adjustment to have optimal result. This method could be applied to local extrema detection on various sport such as driving (or recovery) phase of rower movement in rowing ergometer, and cadence deduction based on knee joint angle change in cycling, etc.

Reference

1. *Bideau, B., "Development of an active Drag Evaluation System (A.D.E.S.)", In J. C. Chatard (Ed.), Biomechanics and medicine in swimming IX (pp. 51-56). Publications de l'Université de Saint Etienne, France.*