USING TYPES OF FORCE PLATFORMS FOR MEASURING RELAYS EXCHANGE TIME IN SWIMMING

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INTRODUCTION

In order to use the capability of computers in non sophisticated meaurements of time and other parameters in biomechanics, an interface is needed which is less complex than the standard interface. The standard is the following. (1) Sensors are used to convert the biomechanical quantities to be measured into electrical quantities such as voltage, resistance, capacitance or inductance. (2) Amplifiers are used to convert these quantities into a suitable analog voltage. The amplifier often includes bridge components , low votage rectifiers, filtering circuits and elements for adjusting level and offset of the output. (3) A multiplexer is needed when more than one channel is measured. (4) an analog to digital converter (ADC) is needed, In order to avoid this complexity, an interface was developed which reduces the expediture to3-10% of the usual one.

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METHOD

1. Interface

A voltage source, a resistor and a cpacitor are connected in series, the input of a timer IC is connected in parallel to the capacitor. First, the input is shorted inside the IC, so the capcitor starts loading. After PXC seconds, the capacitor voltage is 63% of the supply voltage, then the input is shorted again and an impuls is fed into the computer which measured the time difference between this impuls and the trigger impuls by means of ahardware clock which is integrated into some computers or by means of a software clock, when either voltage source, resistor or capacitor ane capacitor are replaced by a sensor of the same type, the biomechanical quantity to be measured can be calculated from this time difference. In this way the amplifier and the ADC are avoided. Moreover, when there are more than one channel, the output pulses of all channels are ad- $_n$x C $_n$are fed into the same input line of the computer. As the time constants R justed to form a sequence, the impulses appear in the same sequence and can be refered to the channels by software. In this way the multiplexer is avoided.

This system has several advantages. (1) Simplicity. Only one timer is needed for one channel, so a standard quad timer IC is sufficient for four channels. (2) Flexibility in quantities to be measured. The same circuit can be used for sensors of either voltage type (also amplifiers), resistor type (also switches) or capacitance type. (3) Flexibility in the data of the system. Resolution r and frequency f can be deliberately chosen, Provided two systems of this kind have been set up till now. A two-channel system is used by a swimming club in Munster, West Germany, a six-channel system is set up at the University of Iowa. The systems are used for he measurement of block time, relay exchange time, contact time while performing turns, swimming time for one lane, intermediate time for relays.

APPLICAION AND RESULTS

of particular interest were the exchange time in relays, this investigation will be reported in some detail.

At the University of Iowa up to three lanes were used simultaneously. The exchange time which was output by system was reported to swimmers after every trial.

In order to compare the average of trials and of subjects, taking into account early starts, a cost- function c was defined:

c = t / 10 ms, if t is positiv (late start)

C = (t/t0)2xt0/10ms,t is negative .

f/ is less than clock rate.

Sensors which were developed in our laboratory were used together with the interface described. These are: Uitrasound velocity meters, Uitrasound distance meter (range 5m, resolution. 1mm), correlation type photo electric cells (all voltage type sensors), special goniometers for recording the movement of a mechanical gymnast (resistance type), and capacitance type force platforms.

In particular we use capacity type force sensors of 7 x 5 x 1 mm size. The ranges are O...500N, the resolution of the 2ON type is. 04N at 50Hz. Unlinearity and hysteresis ane + 2%.

2. Set up of the swimming systems

For the measurement of time characteristics in swimming we use low cost switching mats as sensors which are connected in series to the loading resistors. A battery powered microcomputer Epson Hx-20 is used, the battery of which also powers the interface So, no electrical hazards are faced when working at the pool-side The mats are fixed at the starting blocks and wall of the pool. The starting signal is generated by the computer and amplified by a transistor radio.

Table 1. Relation between exchange time and cost - function

Exchange time (10 ms)	12 - 9 - 6 - 3 0 - 3 - 6 - 9 - 12 - 15 -
cost - function	48 - 27 - 12 - 3 - 0 - 3 - 6 - 9 - 12 -

Table 1 gives C in relation to t for to = 30ms. It is intended that Cindicates for

early starts the time advantage and the risk of disqualification. The amount of disadvantage of a disqualification is entered by the constant to. It is no question that C can be defined in many other ways, nevertheless C is used in the following for comparison as no way is seen how to do this in a much more appropriate manner.

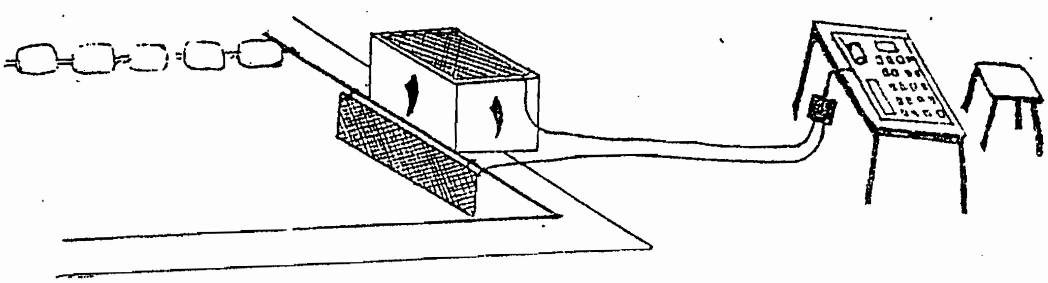

Table 2. Exchange time (time) and cost - functions (cost - fu.) for women's team (subject 1-3) and men's team (subject 4-13). University of Iowa. Negative time means start was early.

	Exchang time (10ms) for trial			cost-function (subjects for time tine difference			
	1	2	3	time	1-2	2-3	1-3
Subj. 1	0	-2	4	1-7	-1	-3	- 4
Subj. 2	16	7	20	14 -3	9	-13	-4
Subj. 3	-8	4	1	8 .7	17	3	20
cost-fu. (trials)	12.3	4.0	8.3	8.2	8.3	- 4.3	4.0
Subj. 4	-1	4		2.0	-4		
Subj. 5	.25	0		12.5	25		
Subj. 6	6	6		6.0	0		
Subj. 7	10	-4		7.5	5		
Subj. 8	-2	-4		3.0	-4		
Subj. 9	8	-1		4.0	8		
Subj. 10	5			5.0.			
Subj. 11	16			16.0	-		
Subj. 12	8	7		7-5	-		
Subj. 13	0	0		0-0	-		
cost-fu. (trials)	7.9	3.4		6.3	3.9		

First three members of the women's team were investugated, the exchange times are given in table 2. The average rates of C for the subjects are given in column 5, the average rates for the trials are given in line 4. It is seen that C decreases (i. the quality of the exchange increase.) from trial 1 to trial 2 and from trial 1 to trial 3, whereas trial 3 is worse than trial 2. In column 6 to 8 the cost-fuction for the intraindividual variations are given, line 4 contains the average values. Is seen that by far not all trials were improvements, though in total an iprovement can be stated. The investigation of the men's team yields better result: the cost-function was reduced to less than a half and nearly all subjects improved their capability.

Nevertheless it turned out that a more intensive study is needed for establishing that the feedback really improves the exchange times. This investigation is now under progress in Munster. In particular it is planned to use the capability of the computer, to compare every measurement to standards, to make decisions and to output the decisions to the swimmers acoustically. So, the swimmer will have information about block time, exchange time, contact time while performing turns - for comparison with a previous study (Nicol and kruger, 1979) - and swimming time for one lane without the assistance of the coach.

ACKNOWLEDGEMENT

This research was supported in part by Deutecher Sportbund, West Germany.

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