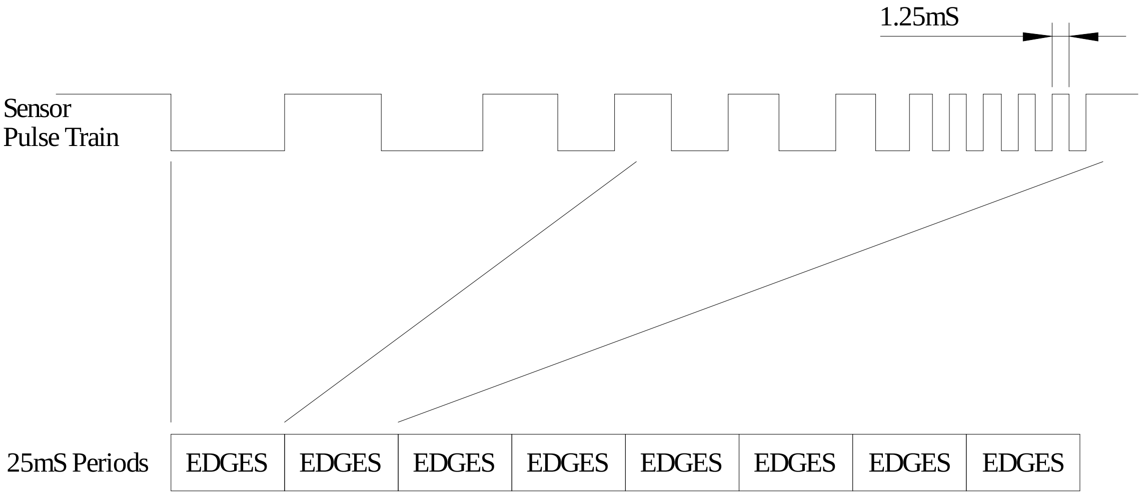
Water Rower Series 4 Rowing Algorithm

The following details the methods and algorithms used to determine acceleration, deceleration and distance rowed. The two are separately dealt with once the initial sampling has been completed.

To obtain samples the unit counts the number of detected edges over a single 25mS period (0.025s), these edges are low to high and high to low transitions. As the paddle is rotated faster/harder during the stroke then the more counts are recorder per 25mS sample, during the recovery phase the number of counted edges reduces as the paddle slow.

Typically the acceleration is determined up to a maximum 1.25mS edge to edge count, any faster and the unit will indicate for acceleration, that the max limit has been reached, however the rower would be only able to sustain such speed for a short time physically, hence it does not cause a concern and does not effect the detection of the acceleration. Distance is unaffected by this limit as it is handled separately.

These samples are totalled together as will be explained later to calculate the acceleration/deceleration or the distance covered. Below is a diagram which show's a typical pulse train from the sensor over two 25mS sample periods. It can be seen that in the first sample there are 6 detected edges and in the second sample there are 16 detected edges.



Naturally this diagram is exaggerated to make a point and that is as the rower starts the stroke pull phase the pulses rapidly increases, however in reality this acceleration may be seen as equal numbers of edges to the last count or +1 or +2. Therefore the number of edges per sample will typically range from 0 to 20 and during acceleration will increase or equal the last value.

During deceleration (stroke recovery phase) the detected edges varies as first, the paddle slows causing the water to build up a pressure wave behind it, which then forces it to spin a little faster than it had been, this is due to the lack of water directly in front of said paddle. Once the paddle has taken the energy from the water wave and moved around a little faster the build up of water in front of the paddle then slows it again, this then returns us back to the wave pressure build up earlier on the back and the whole phase repeats.

Why describe this? Well naturally this ebb and flow on the paddle causes a feedback in the samples, which is detectable by the processor and is the main reason for the following acceleration/deceleration algorithm. The total distance is the easy bit as it's just addition and subtraction of a total.

Detecting Acceleration/Deceleration

To many the following will look backwards, there are reasons for this which are at a coding level, however for the human mind is can be seen that the exit maths should be viewed as being performed first then the checks.

The idea is the maths will reduce any ebb and flow values that would cause poor/repeat detection of acceleration/deceleration, this is mainly during the deceleration phase where repeated accelerations were found due to the ebb and flow on the paddle.

The Checks

The acceleration/deceleration is checked every 25mS after the edge sample has been counted; “totalling_new” and “totalling_old” will contain values that are calculated once the stop/acceleration/deceleration has been determined.

Stop

First “totalling_new” and “totalling_old” are checked for 0.
If both equal zero on 3 repeated checks (75mS) then the program indicates a stopped rowing condition and jumps to the “Exit maths”, otherwise if a value is present then a check for acceleration/deceleration is performed.

Acceleration/deceleration

First “totalling_new” is checked to be greater than “totalling_old”
If it is greater then we check the “acceleration criteria”, but if it is less than or equal in value then we check the “deceleration criteria”.

Acceleration criteria

If the value is greater 3 times in a row (75mS) then acceleration has been detected and a new stroke is indicated. Once the check is completed we jump to “Exit maths”

Deceleration criteria

If the value is less than or equal 3 times in a row (75mS) then deceleration has been detected and the end of stroke is indicated. Once the end check is completed we jump to “Exit maths”

Exit Maths

The exit maths is simply a FIFO (first in, first out) buffer and a set of additions, before the addition and FIFO buffer are modified, the current “totalling_new” value to put in to “totalling_old”. This means that on the next check in 25mS time the last new value (now old) will be available for the above checks.

Below is a diagram that indicates 18 edge samples, there are no values to these samples, just that they are edge samples and this would be an instance in time covering 450mS. It is assumed that this is a very first stroke and the paddle was stopped to begin with, this allows a clearer indication of the maths and it’s function.

Edges per 25mS Period	EDGES 1	EDGES 2	EDGES 3	EDGES 4	EDGES 5	EDGES 6	EDGES 7	EDGES 8	EDGES 9	EDGES 10	EDGES 11	EDGES 12	EDGES 13	EDGES 14	EDGES 15	EDGES 16	EDGES 17	EDGES 18

CURRENT EDGES	EDGES 1	EDGES 2	EDGES 3	EDGES 4	EDGES 5	EDGES 6	EDGES 7	EDGES 8	EDGES 9	EDGES 10	EDGES 11	EDGES 12	EDGES 13	EDGES 14	EDGES 15	EDGES 16	EDGES 17	EDGES 18
LAST EDGES 01		EDGES 1	EDGES 2	EDGES 3	EDGES 4	EDGES 5	EDGES 6	EDGES 7	EDGES 8	EDGES 9	EDGES 10	EDGES 11	EDGES 12	EDGES 13	EDGES 14	EDGES 15	EDGES 16	EDGES 17
LAST EDGES 02			EDGES 1	EDGES 2	EDGES 3	EDGES 4	EDGES 5	EDGES 6	EDGES 7	EDGES 8	EDGES 9	EDGES 10	EDGES 11	EDGES 12	EDGES 13	EDGES 14	EDGES 15	EDGES 16
LAST EDGES 03				EDGES 1	EDGES 2	EDGES 3	EDGES 4	EDGES 5	EDGES 6	EDGES 7	EDGES 8	EDGES 9	EDGES 10	EDGES 11	EDGES 12	EDGES 13	EDGES 14	EDGES 15
LAST EDGES 04					EDGES 1	EDGES 2	EDGES 3	EDGES 4	EDGES 5	EDGES 6	EDGES 7	EDGES 8	EDGES 9	EDGES 10	EDGES 11	EDGES 12	EDGES 13	EDGES 14
LAST EDGES 05						EDGES 1	EDGES 2	EDGES 3	EDGES 4	EDGES 5	EDGES 6	EDGES 7	EDGES 8	EDGES 9	EDGES 10	EDGES 11	EDGES 12	EDGES 13
LAST EDGES 06							EDGES 1	EDGES 2	EDGES 3	EDGES 4	EDGES 5	EDGES 6	EDGES 7	EDGES 8	EDGES 9	EDGES 10	EDGES 11	EDGES 12
LAST EDGES 07								EDGES 1	EDGES 2	EDGES 3	EDGES 4	EDGES 5	EDGES 6	EDGES 7	EDGES 8	EDGES 9	EDGES 10	EDGES 11
LAST EDGES 08			Values Start Zeroed						EDGES 1	EDGES 2	EDGES 3	EDGES 4	EDGES 5	EDGES 6	EDGES 7	EDGES 8	EDGES 9	EDGES 10
LAST EDGES 09										EDGES 1	EDGES 2	EDGES 3	EDGES 4	EDGES 5	EDGES 6	EDGES 7	EDGES 8	EDGES 9
LAST EDGES 10											EDGES 1	EDGES 2	EDGES 3	EDGES 4	EDGES 5	EDGES 6	EDGES 7	EDGES 8
LAST EDGES 11												EDGES 1	EDGES 2	EDGES 3	EDGES 4	EDGES 5	EDGES 6	EDGES 7
LAST EDGES 12													EDGES 1	EDGES 2	EDGES 3	EDGES 4	EDGES 5	EDGES 6

The FIFO buffer is indicated as values “LAST EDGE 01” to “LAST EDGE 12”. The maths adds “current edges” and each value in the FIFO buffer from “LAST EDGE 01” to “LAST EDGE 12” together to make a total that is put in “totalling_new”.

Once the maths addition is complete the buffer is modified such that entry “12” is binned and “11” takes it’s place, entry “10” is moved to “11”, “09” to “10”, “08” to “09” etc. This is repeated until entry “01” is free for the value of “current edges” to be placed in it.   The “current edges” is then cleared ready for the new count to begin over the next 25mS sample.

In essence this is a HUGE averaging routine, it removes the ebbs and flow’s on the paddle as well as gives good positive values which once checked over multiple times will indicate an acceleration, deceleration or stop.   It can be seen that a new stroke can be detected within 100mS of the stroke starting which gives a very good response.

The “totalling_new” and “totalling_old” can also indicate the speed of acceleration/power as the difference between them at each 25mS can be found. Where a weak pull is performed the value difference between these two will be fairly close while during a very powerful pull the value will be quite high.

Naturally at any instance in time this value will change from the start of the stroke where they will be close in value, to the middle of the stroke where most power is exerted (be it a weak or hard pull) and they will be greater apart.

There would be no requirement for this kind of value during deceleration, as it would result in a negative value.   The “totalling” value as can be seen from all the above indicators are kept to below 255; this is typical for 8bit mathematics.

Distance/Intensity

At each 25mS sample period the edge maths is performed, simply a number of edge counts are added together and when a specific value is reached a new distance in cm is added to the distance decimal value, this allows varying of the stroke to distance rowed.

At present the rowing ratio is set to 1m of pull is equal to 2.667m of travel. This is controlled by the following two values:

Pins_per_xxcm = 30	this is the number of edges which must be counted up to
Distance_xxcm = 25	this is the distance travelled every time "pin_per_xxcm" is exceeded

Edges maths

Ok, all may seem confusing, so lets clarify what happens:

First the current sample of edges is added to the "distance_pins" total.

Next this value is compared to "pins_per_xxcm", where the total value has exceeded or is equal to "pins_per_xxcm" then we deduct the "pins_per_xxcm" value from said total, this reduces it back under the value of "pins_per_xxcm". The program then flags a new distance has been reached which will be totalled up later for both the total distance and the 1second intensity display.

Total distance maths

When the program finds the time it will add up the total distance and 1second intensity maths. First the total distance will be added up as follows:

"distance_xxcm" is added to the total "distance_dec" which is the decimal cm's total.

"distance_dec" is then checked to be greater than or equal to 100 (cm). If it is, then 100 is deducted from "distance_dec" total and 1 is added to the distance meters total.

Therefore the number of pins per cm distance can be modified to adjust for the exact distance per stroke and the distance can count up using different values.

The distance meters total is what is displayed for the user to see and can range from 0 to 65535meters. Miles and km are either calculated from meters or adjusted to be display on screen accordingly. ALL measurements start from meters for distance. Strokes are counted independently of distance and has no effect on the distance rowed.

1second intensity maths

The following is performed after the total distance maths has been completed and the produced total is used to update the intensity window every second.

Each time the new distance if flagged this routine adds the value of “distance_xxcm” to “ms_total”. This value will increase over a second of flagged distances and when the 1second flag is triggered the next phase of the maths for the intensity can begin.

Intensity Maths

Like the edge samples, the intensity maths uses a 16-value FIFO buffer, however this routine modifies the contents of the buffer first and clears the “ms_total” ready for the next addition when the next new distance is flagged.

Naturally it can be seen that this buffer is in effect a 16 second storage of time, this is to smooth out the display values. It takes a typical stroke and recovery to be completed is say 3-4 seconds which if instantaneous values were displayed would result in jumpy values during stroke and recovery, so 16 seconds gives a smoothing of the last 3-6 strokes.

To simplify how the program works we will assume there are 16 values already stored, once the new value has been stored in the FIFO buffer then the values are all totalled together and divided by, in this case 16. This gives an average meter per second (ms) value which can be used straight to the display for m/s in the intensity screen of modified to generate mph, split 500m and 2000m time interval’s.