SYSTEM OF INTEGRATED PRENATAL CARE

Dolinay V., Lampart M., Vašek V.
Tomas Bata University in Zlín, Faculty of Applied Informatics
Nad Stráněmi 4511, 760 05 Zlín
Czech Republic

ABSTRACT
This contribution describes methods of processing signals measured by special body belt which is used to monitor pregnant women. As a part of previous research a belt dedicated to clasp belly of pregnant women with potential problems during the gravidity was designed. The task is to monitor movement of the belly with focus on catching the moment and length of contraction. Output data are values of belt tension measured by strain gages placed at the ends of belt. These raw data has to be filtered first and than analyzed to find the contractions. For this task three simple filter algorithms were proposed. After their testing it was found, that best results are obtained from their mutual combination. After filtering is done the data are processed by special algorithm to determine whether we found contraction and eventually in what period the contractions are repeating. All above mentioned algorithms are implemented in an experimental program which also performs reading data from belt memory and simple visualization. This paper aimed to describe methods of data filtering algorithm.
Keywords: pregnancy, belt, body, pressure, filtering

1. INTRODUCTION
The invented special body belt monitors pregnant women during risky section of pregnancy. Stream of relative pressure values produced by belt must be filtered before finel analyse and visualization. In this case quick motion and breathing of examined woman is typical source of noise.

2. SOLUTION
There were arranged three easy methods which will construct from a group of initial values one new value – this value will approximate real situation of the up to now process. Each of three methods comes from the same kernel process.
The kernel of designed algorithm is the procedure of finding a centre of gravity of a triangle in the plane and comparing such a center of gravity with the following values.

Firstly, let us denote *D* as a set of initial data. One can imagine this set as a sequence

$$D := \left\{ [t_i, v_i] \right\}_{i=1}^{k} ,$$

where t_i are times in which we measure values v_i. All the measuring process is passing in finite time interval, so we can assume that the sequence contains k elements. Moreover, the measuring process proceeds in constant time intervals, we have

$$\frac{t_{j+1} - t_j}{2} = c ,$$

for every $j = 1,2,3...(k-1)$.

Now, we will define algorithms (maps) T_1, T_2 and T_3, whose progressing application (compositions) we will receive the final algorithm.

2.1. Algorithm T_1

Algorithm is arranged in such a way that it assigned to a successive triple of points from D the value of gravity of the triangle arranged by this triple of vertexes. The output is a new set of data which contains one third of points with respect to the initial set of data D. Hence, is a map from to define by the formula:

$$T_1 = T_e \circ T_r \ ,$$

where $T_r : D \to D^3$ is defined by the rule

$$T_e\left(\left[\!\left[t_{i+j}, v_{i+j}\right]\!\right]_{j=0}^2\right) = \left[\!\left[t_{i+j}, v_{i+j}\right]\!\right]_{j=0}^2 \ ,$$

where $i = 1,2,3,...,\dfrac{k-\mathrm{mod}_3(k)}{3}$; $[[t_{i+j}, v_{i+j}]]_{j=0}^2$ denotes ordered triple of points $[t_i, v_i]$, $[t_{i+1}, v_{i+1}]$, $[t_{i+2}, v_{i+2}]$, by analogy we will denote ordered senary of points; and $T_e : D^3 \to D_1$ is defined by:

$$T_e\left(\left[\!\left[t_{i+j}, v_{i+j}\right]\!\right]_{j=0}^2\right) = \left[t_{i+1}, \frac{v_i + v_{i+1} + v_{i+2}}{3}\right]$$
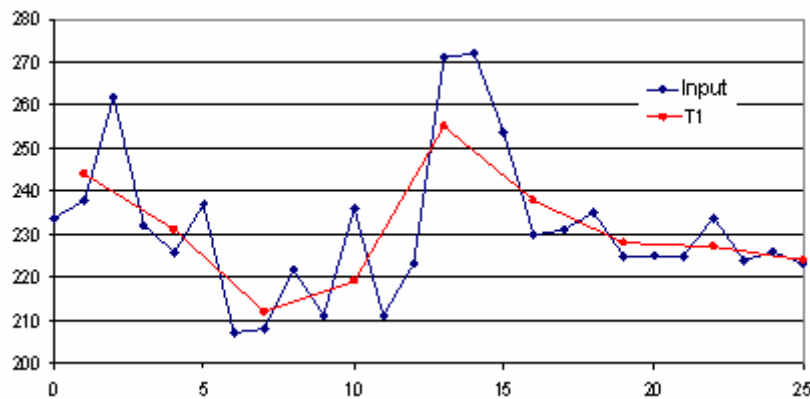

Figure 1. Algorithm T_1.

.

2.2. Algorithm T_2

Algorithm T_2 is arranged in such a way that it assign to each triple of points from D_1 (resp. D) the value of gravity of the triangle arranged by this triple of vertices and then it compares this value of gravity with the following two values. If both this values are greater or smaller then the value of the value of gravity, then it replaces the second one with the value of gravity. If one of these values is greater and second one smaller, then it replaces the foregoing triple by new value of gravity. The output is a new set of data D_2. Consequently, T_2 is a map from D_1 to D_2 defined by:

$$T_1 = T_{es} \circ T_s$$

where $T_s : D_1 \to D^6$ is defined by

$$T_s\left(\left[\!\left[t_{i+j}, v_{i+j}\right]\!\right]_{j=0}^5\right) = \left[\!\left[t_{i+j}, v_{i+j}\right]\!\right]_{j=0}^5,$$

here $i = 1,2,3,...,\dfrac{k-\mathrm{mod}_6(k)}{3}$ and $T_{es} : D^6 \to D_2$ is defined by

$$T_{es}\left(\left[\!\left[t_{i+j},v_{i+j}\right]\!\right]_{j=0}^{5}\right)=\begin{cases}\left[t_{i+1},te_i\right],\left[t_{i+4},te_i\right]\text{if }v_{i+3},v_{i+4}<te_i,\\\qquad\qquad\text{or }v_{i+3},v_{i+4}>te_i,\\\left[t_{i+1},te_i\right],\left[t_{i+4},te_{i+3}\right]\text{otherwise,}\end{cases}$$

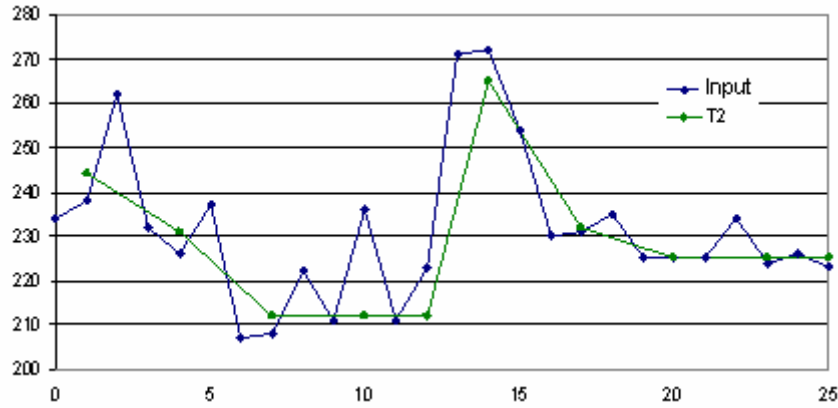where $te_i=\dfrac{v_i+v_{i+1}+v_{i+2}}{3}$.

Figure 2. Algorithm T_2.

2.3. Algorithm T_3

Algorithm T_3 is arranged in such a way that it assign to each triple of points from D_2 (resp. D_1 or D) the value of gravity of the triangle arranged by this triple of vertices and then it compares the foregoing triple of values with the value of gravity. If every point from the triple has the value greater or smaller then the value of gravity, then it replaces the third one with the value of gravity. If one value of the triple is smaller (resp. greater) and the last values of the triple are greater (resp. smaller), then it replaces this triple by a new value of gravity. The output is a new set of data. D_3. Now, T_3 is a map from D_2 to D_3 defined by:

$$T_3=T_{ee}\circ T_s$$

where $T_{ee}:D^6\to D_3$ is defined by

$$T_{ee}\left(\left[\!\left[t_{i+j},v_{i+j}\right]\!\right]_{j=0}^{5}\right)=\begin{cases}\left[t_{i+1},te_i\right],\left[t_{i+5},te_i\right]\text{if }v_{i+3},v_{i+4},v_{i+5}<te_i,\\\qquad\qquad\text{or }v_{i+3},v_{i+4},v_{i+5}>te_i,\\\left[t_{i+1},te_i\right],\left[t_{i+4},te_{i+3}\right]\text{otherwise,}\end{cases}$$

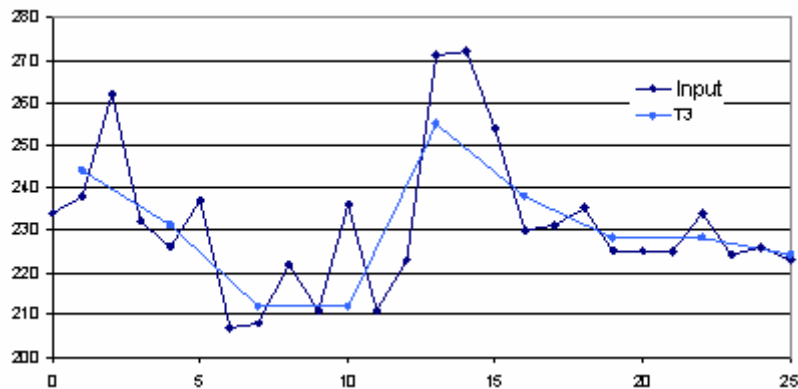where $te_i=\dfrac{v_i+v_{i+1}+v_{i+2}}{3}$.

Figure 3. Algorithm T_3.

1425

3. RESULTING ALGORITH

The resulting algorithm used for filtration of the initial data is the composition of the foregoing algorithms T_1, T_2 a T_3, exactly in this order. Denote it by A.

Finally, A is defined as a map

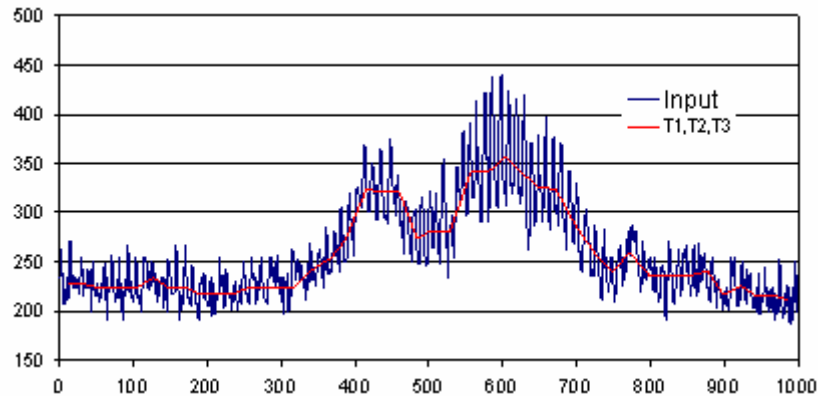$$A : D \to D_3,$$ by the rule $A : T_3 \circ T_2 \circ T_1.$

Figure 4. Algorithm A.

The output depiction is made in a primitive way (i.e., by linear joining of neighbour points from the final set of data).

4. CONCLUSION

The designed algorithm gives surprisingly first rate results. Its best advantage is its easy way to programme it and its unpretentiousness for the hardware. All the algorithm or its parts can be used for filtrating of similar data of other process.

Finally, it was made a faithful to the algorithm to be able to work on real time. It was achieved and it is possible to use this algorithm for a mobile hardware.

The output graph is a piecewise linear map, which is possibly make as a smooth curve by standard methods or by new one

5. ACKNOWLEDGMENTS

6. REFERENCES

[1] Rektorys, Karel: Přehled užité matematiky 1. 7. vyd. - Praha : Prometheus, 2000. ISBN 80-7196-180-9.,

[2] Adams, R. A., Single Variable Calculus (paperback) (Edition: 5) Pearson Education Canada, 2003. ISBN: 0-201-79805-0