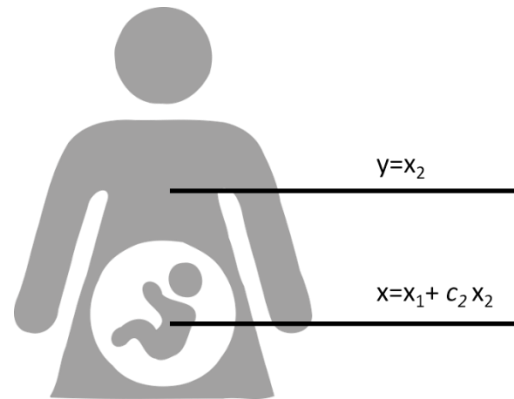


# Assignment 3 – Adaptive filtering

## The aim of the assignment:

To know how to use adaptive filter to remove interfering signal (maternal ECG) summed with the desired signal (fetal ECG).



## Task 1 - Pure sum of signals:

We assume a simple linear model:

$$x(t) = c_1 x_1(t) + c_2 x_2(t)$$

We are able to measure  $y(t) = x_2(t)$  at the same time, and we assume that  $c_1 = 1$ .

Thus,  $x_1(t) = x(t) - c_2 y(t)$ . And to find  $x_1(t)$ , we need to estimate  $c_2$  using:

1. [Scalar projection](#) (formula on grader page)
2. [Moore–Penrose pseudoinverse](#) (formula on grader page)
3. [Backslash Operator](#)

## Task 2 – Delayed sum of signals:

Consider asynchronous signal i.e. one signal is delayed by amount of time (or samples).

time (s)	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6
Signal 1	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>
Signal 2			S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>

Signal 2 is delayed by  $dT = 2$  samples. We need to estimate the value of  $dT$  and match both signals as follows.

time (s)	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6
Signal 1	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>
Signal 2	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>7</sub>	S <sub>7</sub>

The delay  $dT$  can be calculated using [xcorr](#) function (calculates the [cross correlation](#)).

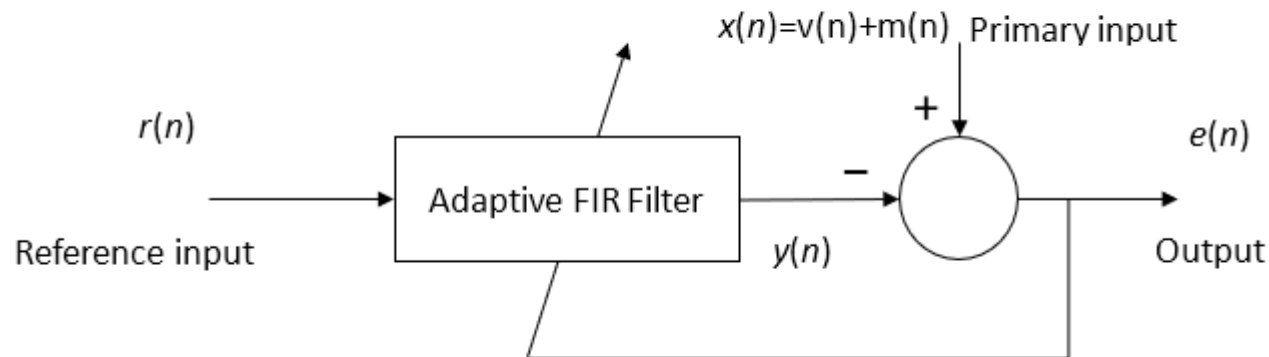
## Task 3 - Delayed sum of signals (subsample accuracy):

In this case one signal is delayed by non-integer amount samples.

time (s)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6
Signal 1	S <sub>1</sub>		S <sub>2</sub>		S <sub>3</sub>		S <sub>4</sub>		S <sub>5</sub>		S <sub>6</sub>		S <sub>7</sub>		S <sub>8</sub>		S <sub>9</sub>
Signal 2				S <sub>1</sub>		S <sub>2</sub>		S <sub>3</sub>		S <sub>4</sub>		S <sub>5</sub>		S <sub>6</sub>		S <sub>7</sub>	

Signal 2 is delayed by  $dT = 1.5$  samples! In this case we interpolate the cross-correlation curve to get the actual delay value.

#### Task 4 – Full adaptive filtering:



**Figure 1.** Schematic diagram of a generic adaptive filter

#### Things to Remember:

1.  $c$  is not the step!
2.  $\text{Step} = \frac{2 \times c \times \mu_{\max}}{m}$
3.  $\mu_{\max}$  is given as an input.
4. Correctly decide which signal is the reference and which one is the error.
5. Follow the code template.
6. Again! follow the code template!
7. Carefully read the documentation of [dsp.LMSFilter](#) and the examples!
8. You need to **save the result of each iteration to compare them** or **do the comparison on the fly using [if statements](#)**.
9. Finally, follow the code template!