Hes·so VALAIS WALLIS
Institute of Information Systems

How to Detect soft falls on ANDROID devices

some signal processing with KNIME

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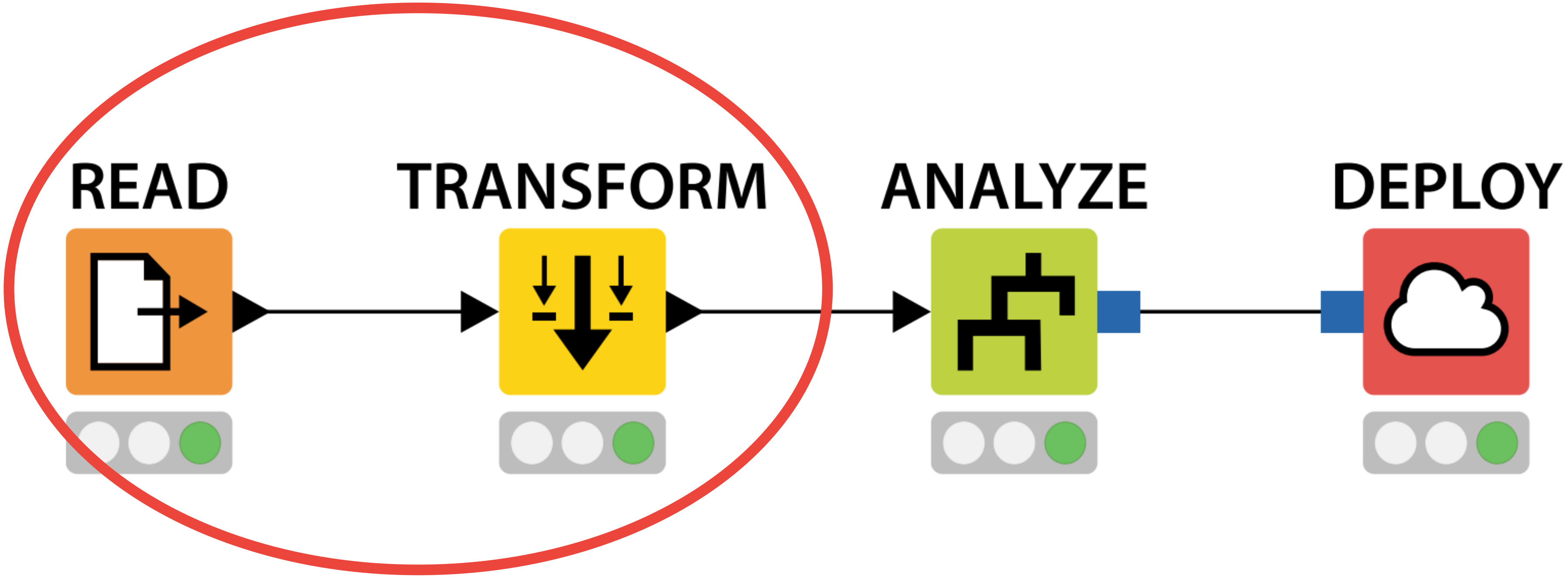
datastory

KNIME Spring Summit 2016 – Berlin

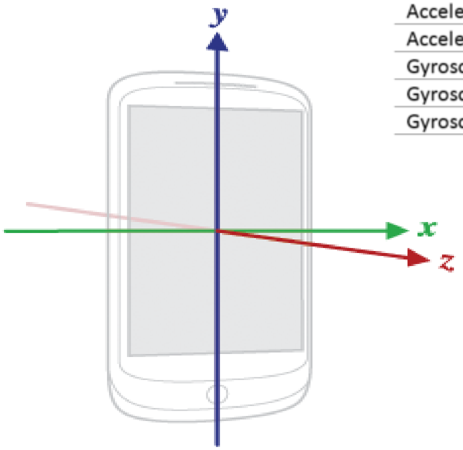
Processing flow



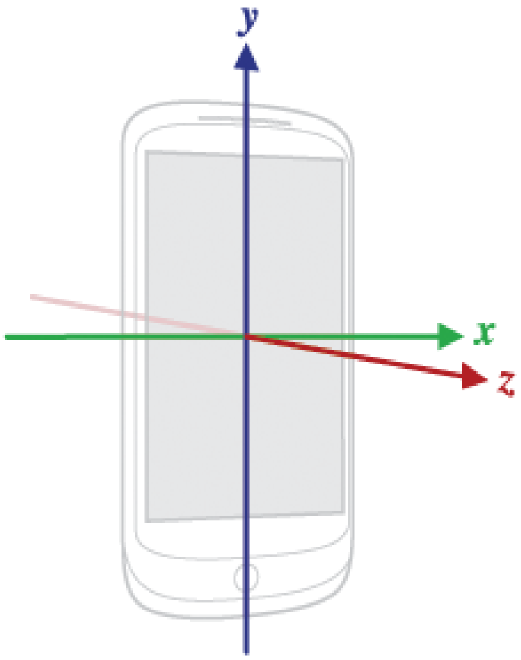
Connected android watches

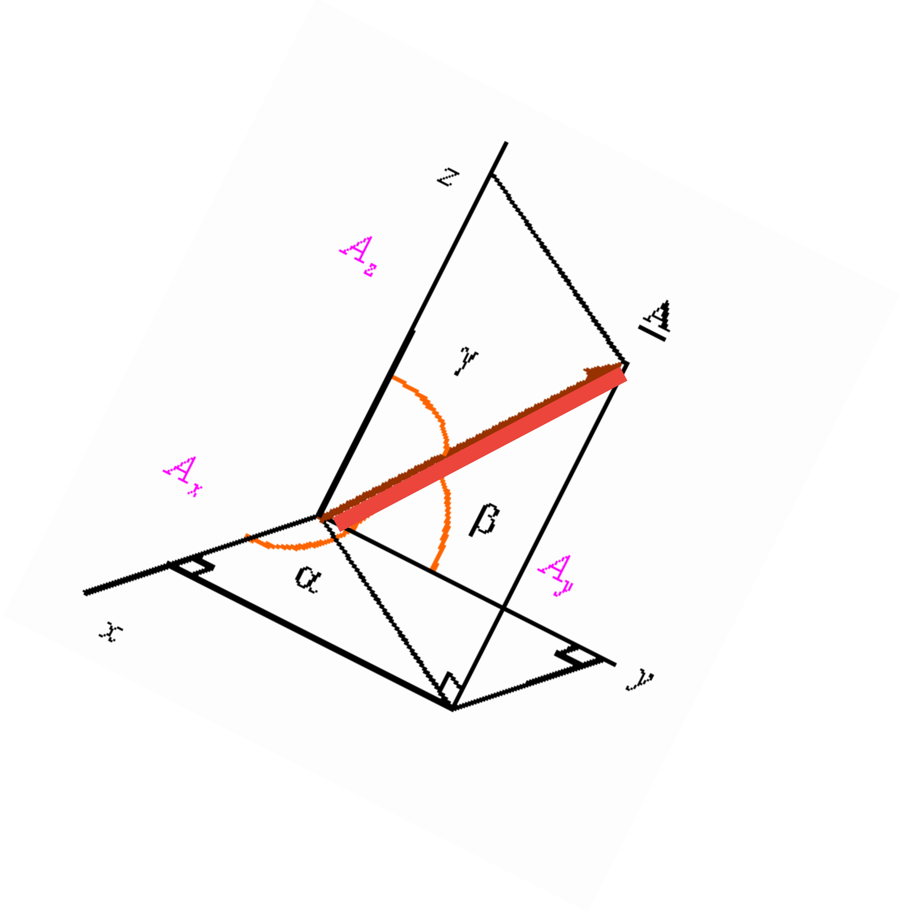
Moto 360 and LG-G watches

Name	Format	Possible values	Type
Fall type	Alphanumeric, 2 symbols	B1, B2, B3, M1, M2, M3, NO, FR	Category
Subject	Alphabetic, 2 characters	AA, BA, BO, FA, GU, KU, LA ; NI, PI, TO, TR, UN, VA	Category
Age	Numeric, 2 digits	[22, 93]	Continuous
Sex	Alphabetic, 1 character	F, M	Category
Auxiliary mean	Alphanumeric, 2 symbols	00, CA, DR, DS	Category
Linear acceleration, X axis.	Numeric	[-34.86532974243164, 33.24461364746094]	Continuous
Linear acceleration, Y axis.	Numeric	[-44.05729675292969, 42.206565856933594]	Continuous
Linear acceleration, Z axis.	Numeric	[-29.68331527709961, 35.54317855834961]	Continuous
Acceleration, X axis	Numeric	[0,0]	Continuous
Acceleration, Y axis	Numeric	[-39.08319854736328, 39.369998931884766]	Continuous
Acceleration, X axis	Numeric	[-38.91899871826172, 39.82899856567383]	Continuous
Gyroscope, X axis	Numeric	[-38.91109848022461, 39.54209899902344]	Continuous
Gyroscope, Y axis	Numeric	[-39.08319854736328, 39.369998931884766]	Continuous
Gyroscope, Z axis	Numeric	[-13.002599716186523, 14.506699562072754]	Continuous

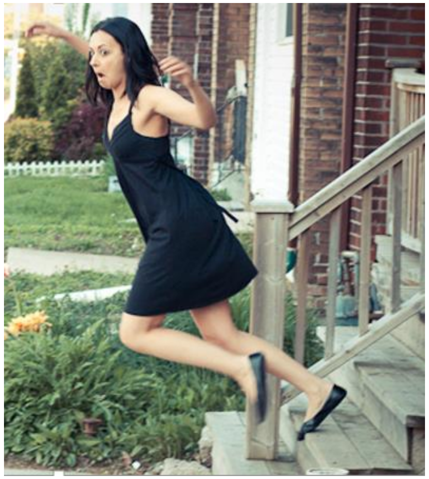


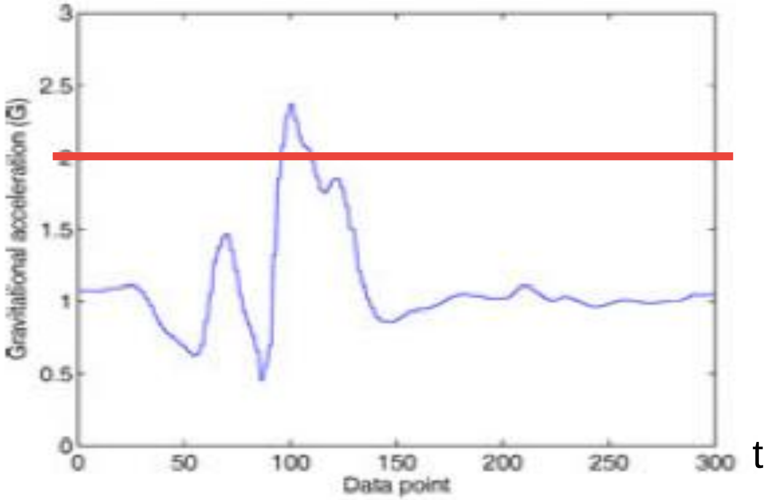
Use the magnitude of 3D vector





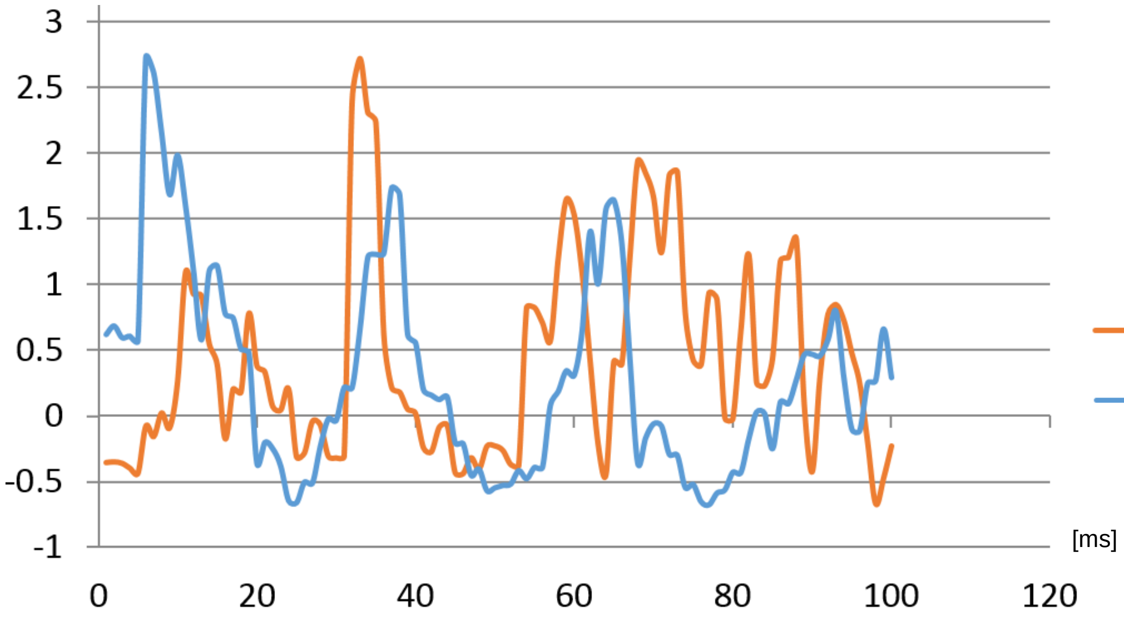
Falls





About 98% detection

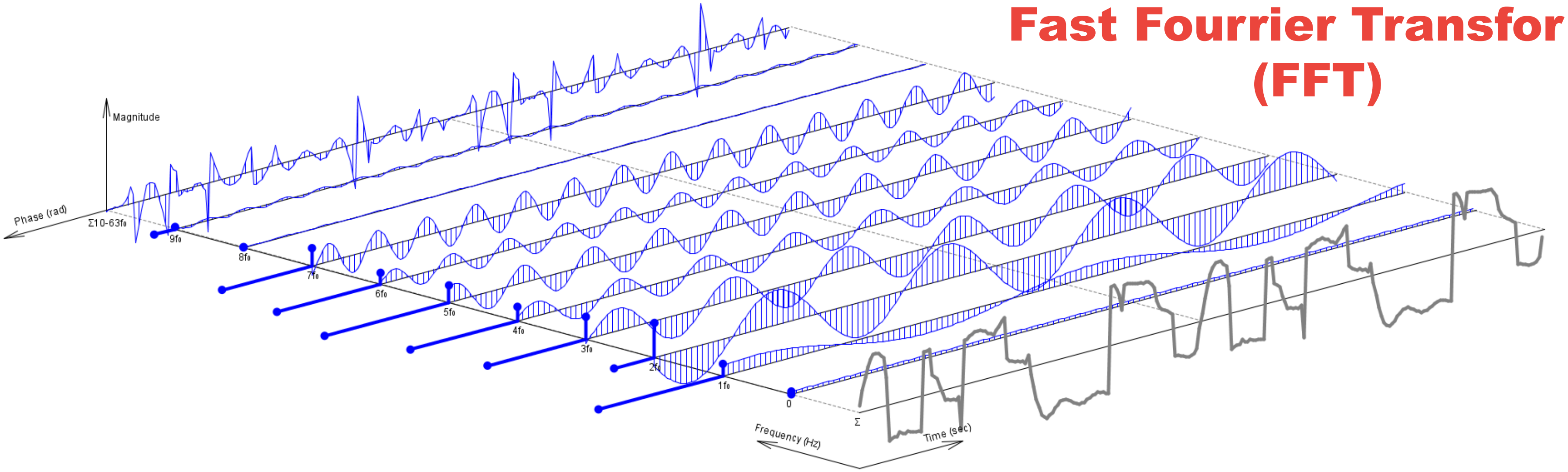
Soft falls



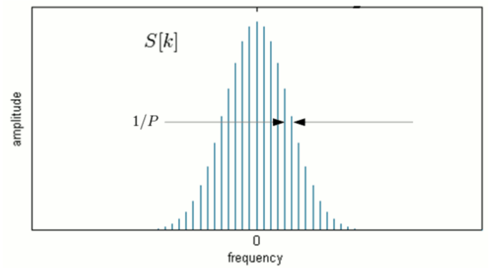
1% detection with thresholds

Signal processing to find patterns

- Decomposition of a temporal signal:



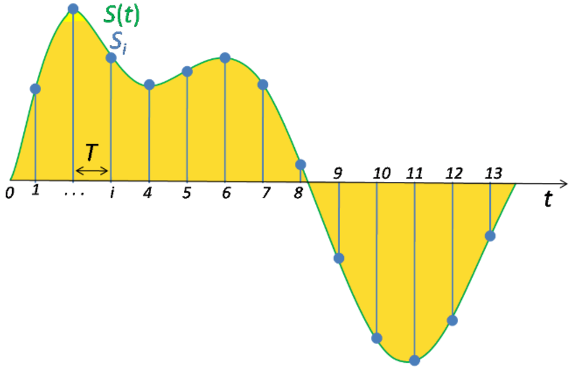
Fast Fourrier Transform (FFT)



In the digital word :

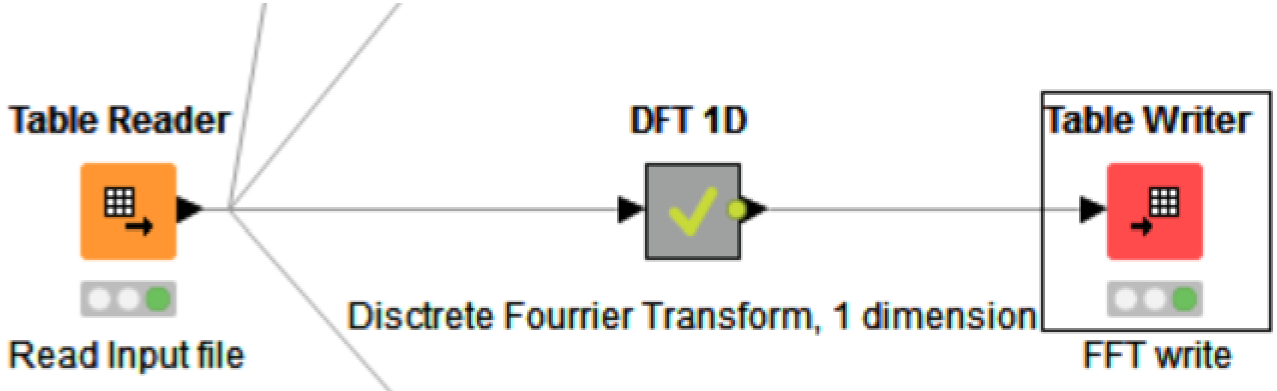
Discrete Fourrier Transform (DFT)

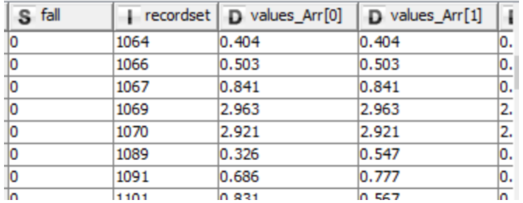
Knime to perform DFT



Reading the samples, and computing the magnitude vector

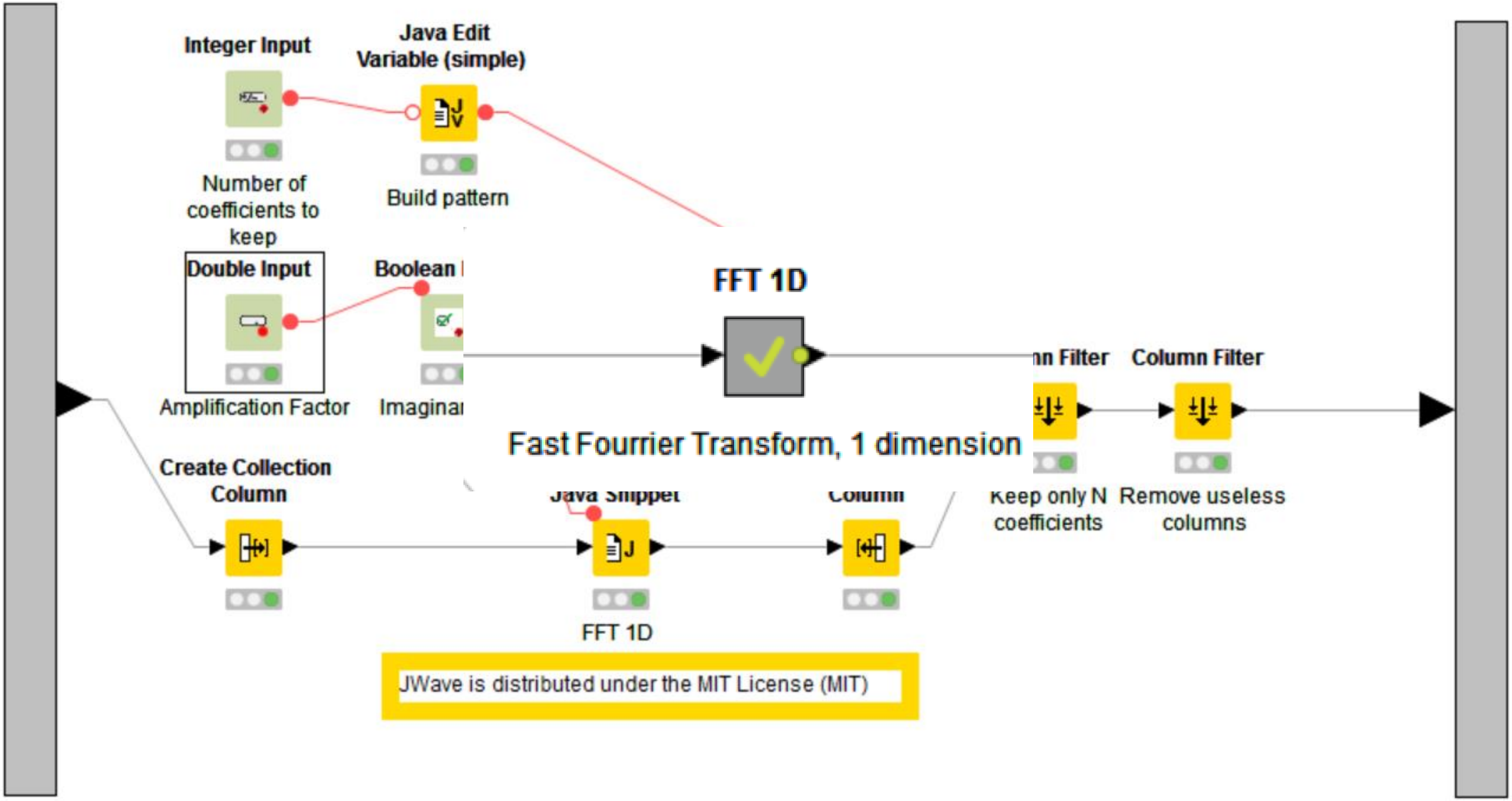
T = 20 ms (50Hz) sampling rate in a window of 128 samples (2.56 seconds)





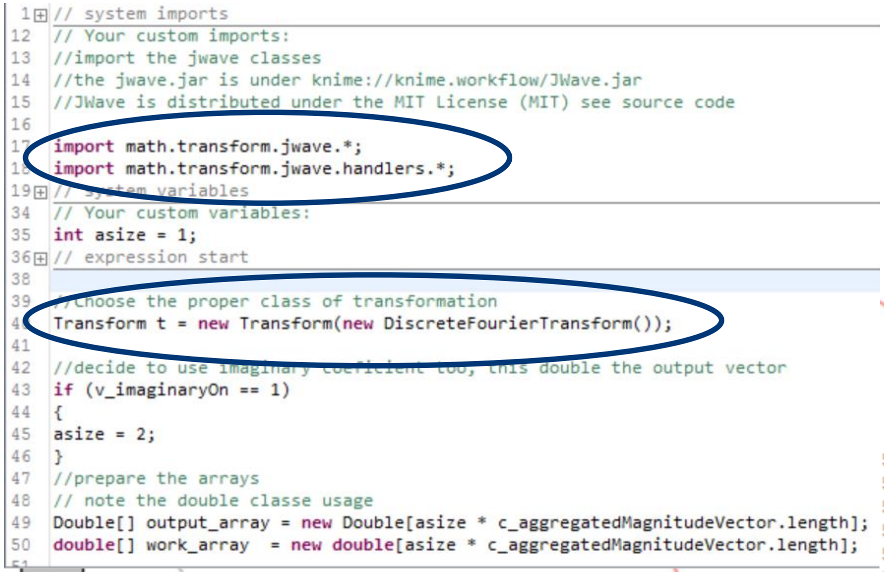
S fall	I recordset	D values_Arr[0]	D values_Arr[1]	I
0	1064	0.404	0.404	0.
0	1066	0.503	0.503	0.
0	1067	0.841	0.841	0.
0	1069	2.963	2.963	2.
0	1070	2.921	2.921	2.
0	1089	0.326	0.547	0.
0	1091	0.686	0.777	0.
0	1101	0.831	0.567	0.

Knime to perform DFT

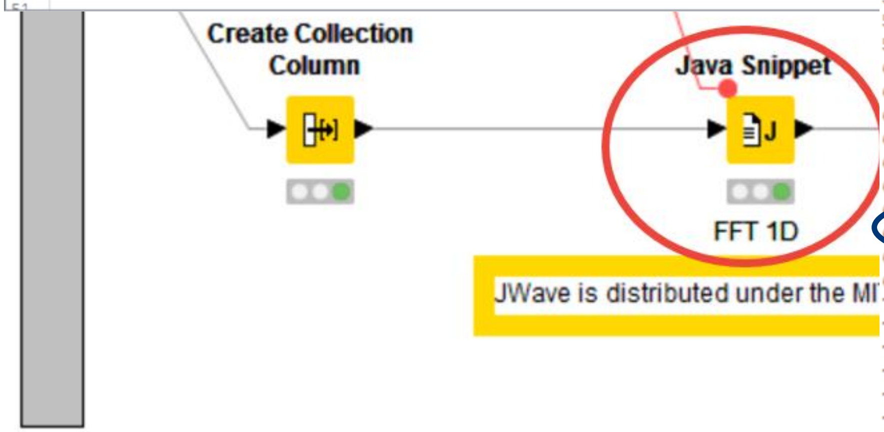


JWave is distributed under the MIT License (MIT)

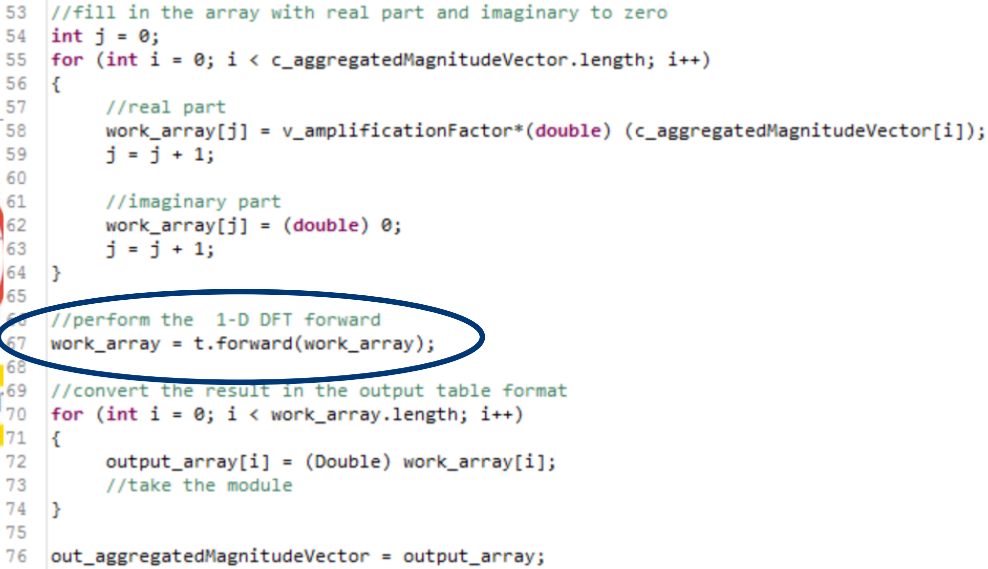
Knime to perform DFT



```
// system imports
// Your custom imports:
//import the jwave classes
//the jwave.jar is under knime://knime.workflow/JWave.jar
//JWave is distributed under the MIT License (MIT) see source code

import math.transform.jwave.*;
import math.transform.jwave.handlers.*;
// system variables
// Your custom variables:
int asize = 1;
// expression start

//choose the proper class of transformation
Transform t = new Transform(new DiscreteFourierTransform());

//decide to use imaginary coeficient too, this double the output vector
if (v_imaginaryOn == 1)
{
asize = 2;
}
//prepare the arrays
// note the double classe usage
Double[] output_array = new Double[asize * c_aggregatedMagnitudeVector.length];
double[] work_array  = new double[asize * c_aggregatedMagnitudeVector.length];
```



JWave is distributed under the MI



```
//fill in the array with real part and imaginary to zero
int j = 0;
for (int i = 0; i < c_aggregatedMagnitudeVector.length; i++)
{
     //real part
     work_array[j] = v_amplificationFactor*(double) (c_aggregatedMagnitudeVector[i]);
     j = j + 1;

     //imaginary part
     work_array[j] = (double) 0;
     j = j + 1;
}

//perform the  1-D DFT forward
work_array = t.forward(work_array);

//convert the result in the output table format
for (int i = 0; i < work_array.length; i++)
{
     output_array[i] = (Double) work_array[i];
     //take the module
}

out_aggregatedMagnitudeVector = output_array;
```

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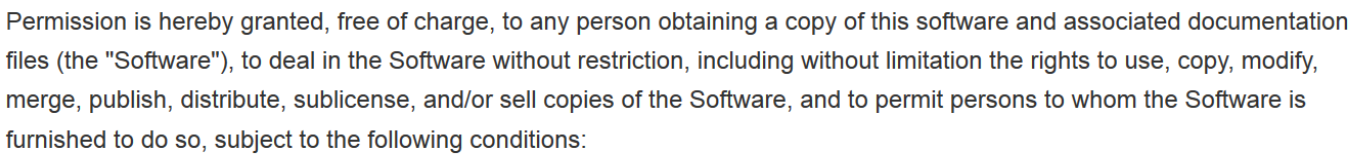
Knime to perform DFT

- Jwave.jar:
  - open source library developed by C. Scheiblich (MIT)
- The source code and examples are available there:
  - https://github.com/cscheiblich/JWave
- License free :



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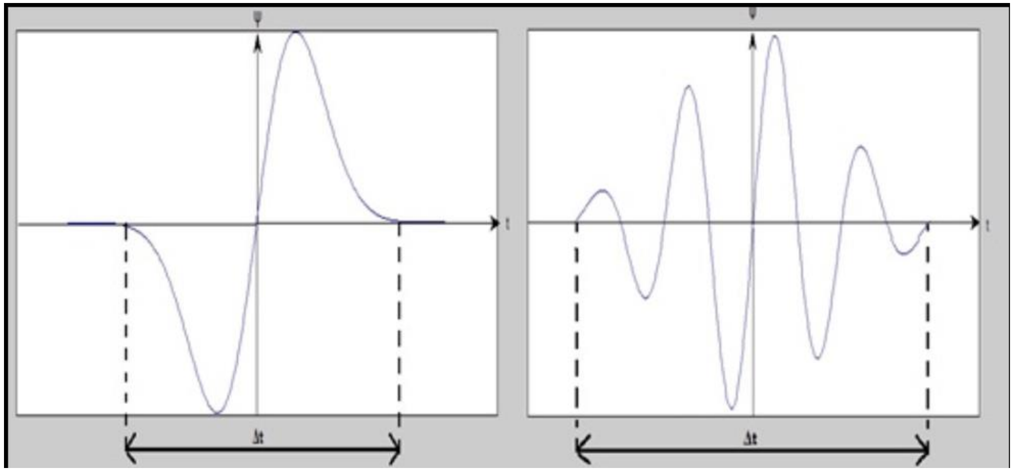
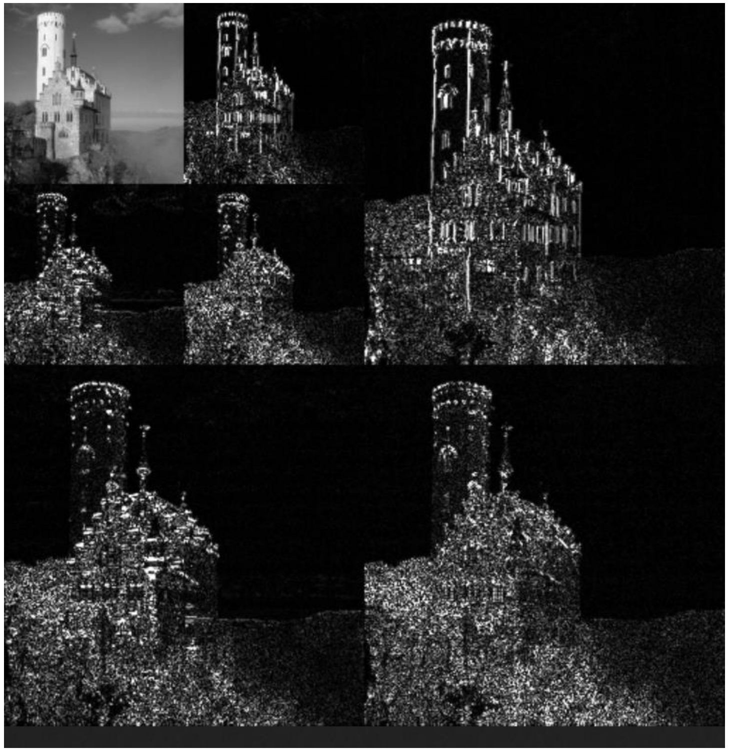
Other polular pattern detection

- Wavelet transform : https://en.wikipedia.org/wiki/Wavelet_transform

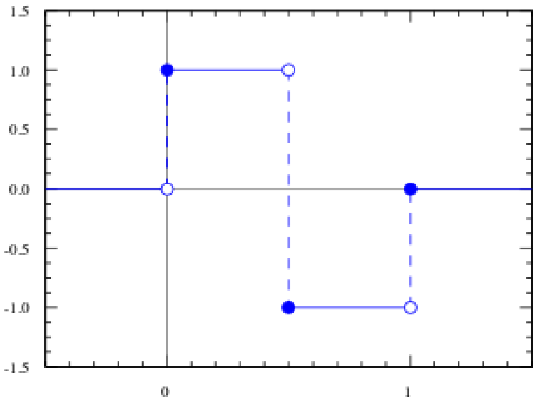




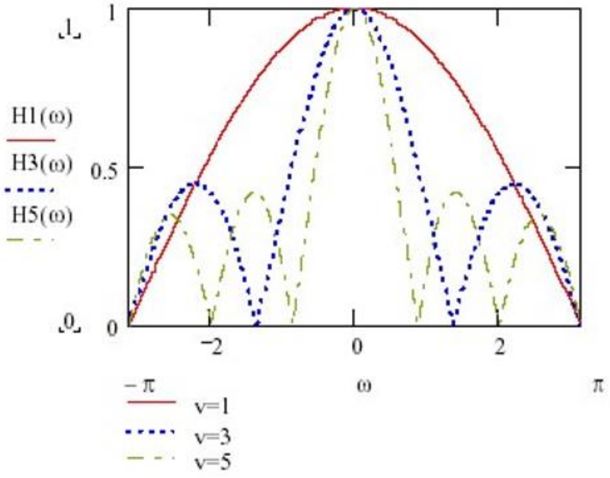
Knime to perform Wavelets

- Implemented in the jwave.jar library:

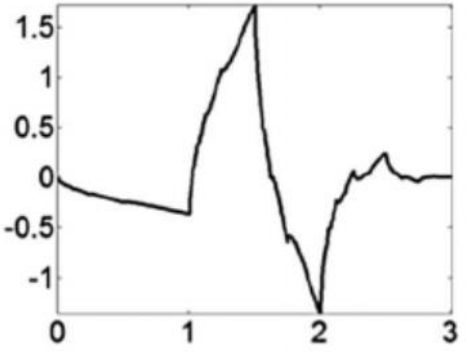
Haare



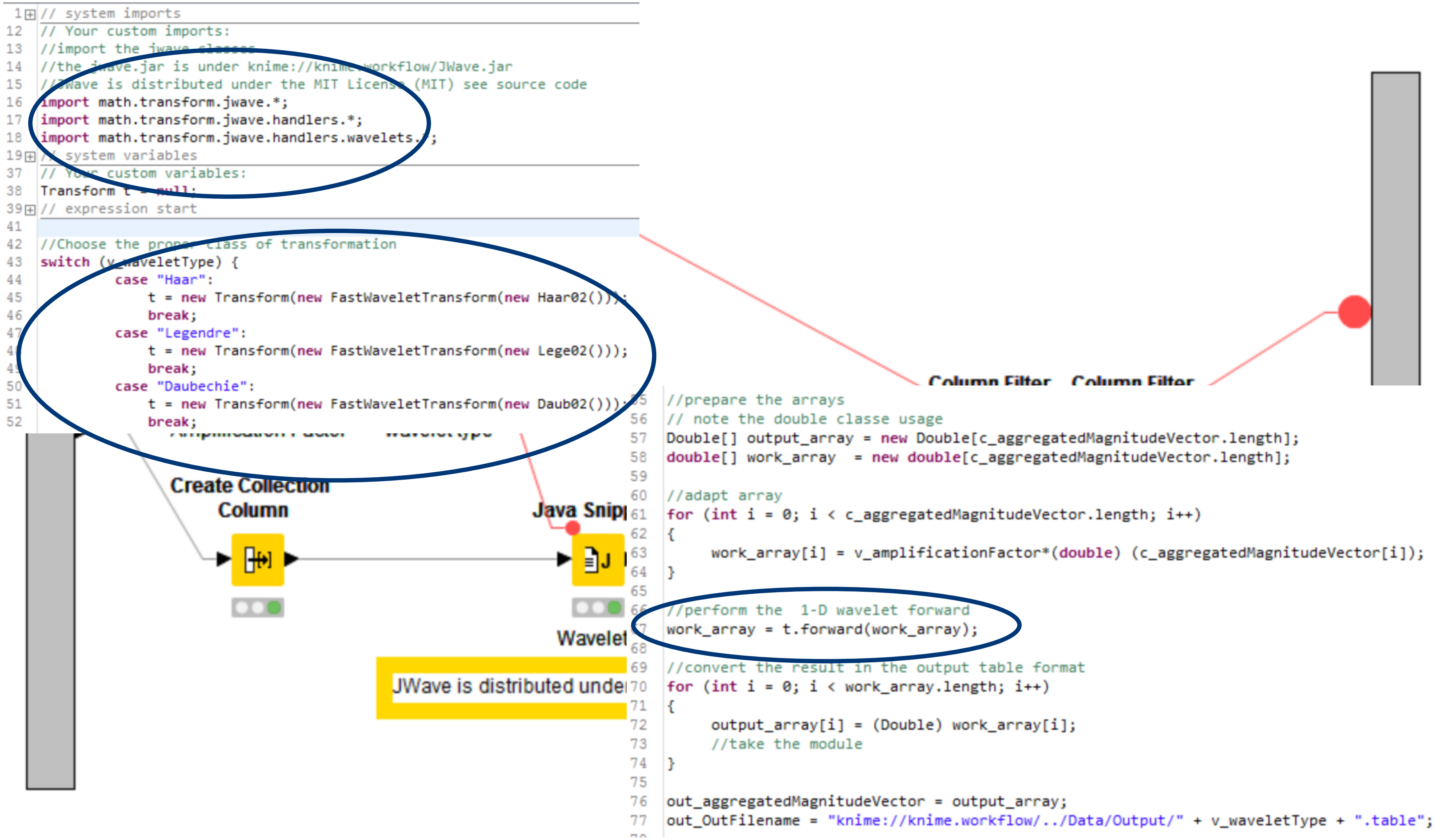
Legendre



Daubechie (db2)



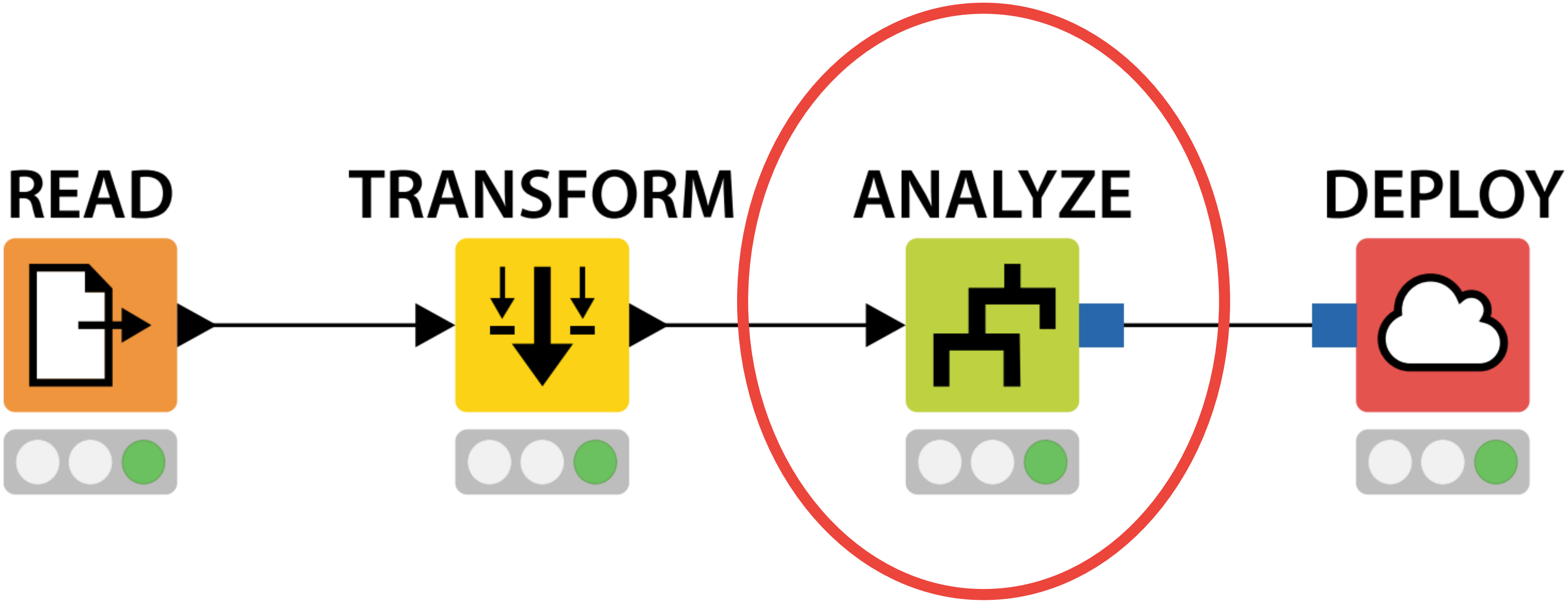
Knime to perform Wavelets



```
// system imports
// Your custom imports:
//import the jwave classes
//the jwave.jar is under knime://knime.workflow/JWave.jar
//JWave is distributed under the MIT License (MIT) see source code
import math.transform.jwave.*;
import math.transform.jwave.handlers.*;
import math.transform.jwave.handlers.wavelets.*;
// system variables
// Your custom variables:
Transform t = null;
// expression start

//Choose the proper class of transformation
switch (v_waveletType) {
        case "Haar":
            t = new Transform(new FastWaveletTransform(new Haar02()));
            break;
        case "Legendre":
            t = new Transform(new FastWaveletTransform(new Lege02()));
            break;
        case "Daubechie":
            t = new Transform(new FastWaveletTransform(new Daub02()));
            break;
```

```
//prepare the arrays
// note the double classe usage
Double[] output_array = new Double[c_aggregatedMagnitudeVector.length];
double[] work_array  = new double[c_aggregatedMagnitudeVector.length];

//adapt array
for (int i = 0; i < c_aggregatedMagnitudeVector.length; i++)
{
     work_array[i] = v_amplificationFactor*(double) (c_aggregatedMagnitudeVector[i]);
}

//perform the  1-D wavelet forward
work_array = t.forward(work_array);

//convert the result in the output table format
for (int i = 0; i < work_array.length; i++)
{
     output_array[i] = (Double) work_array[i];
     //take the module
}

out_aggregatedMagnitudeVector = output_array;
out_OutFilename = "knime://knime.workflow/../Data/Output/" + v_waveletType + ".table";
```

Processing flow



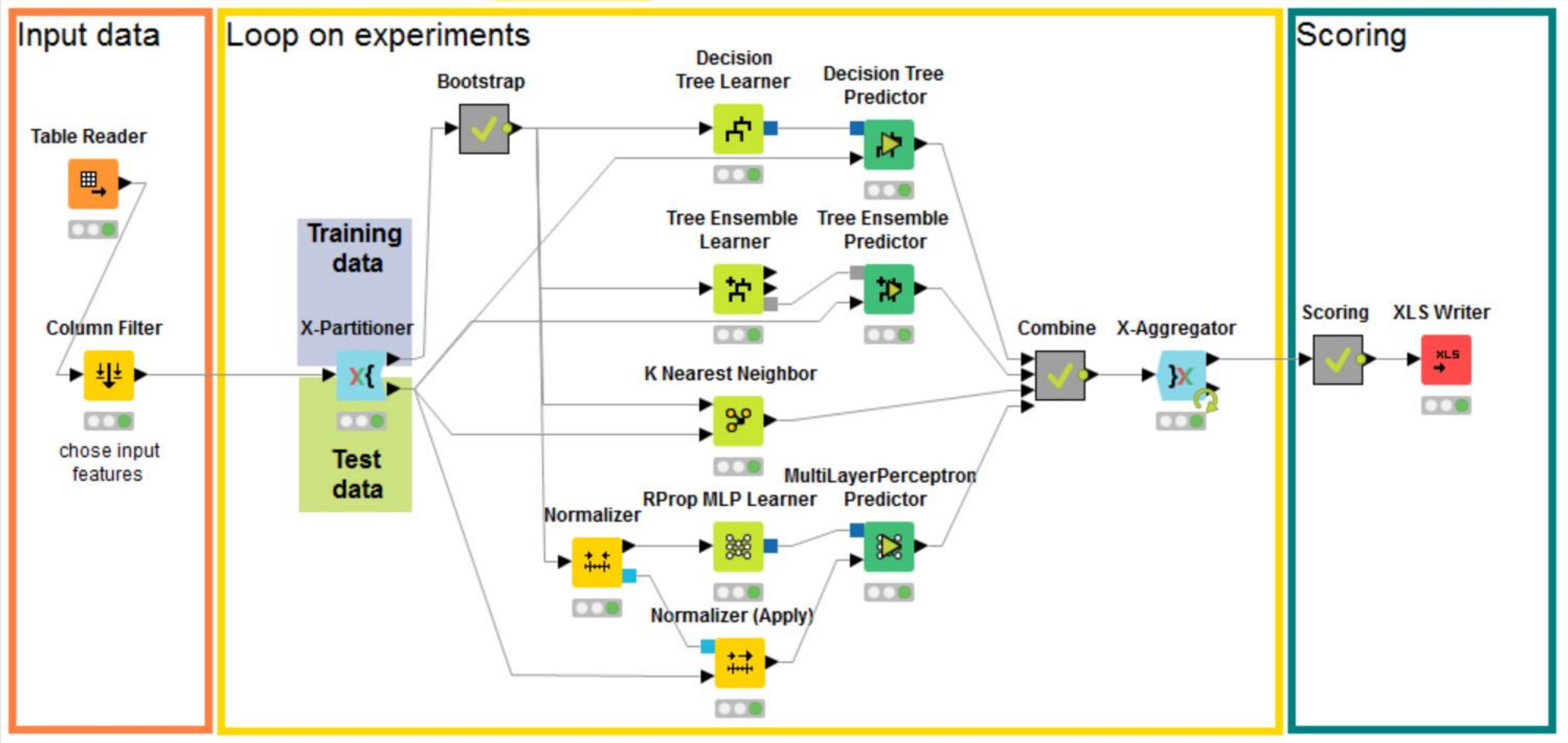
READ

TRANSFORM

ANALYZE

DEPLOY

Classification experiments



Results

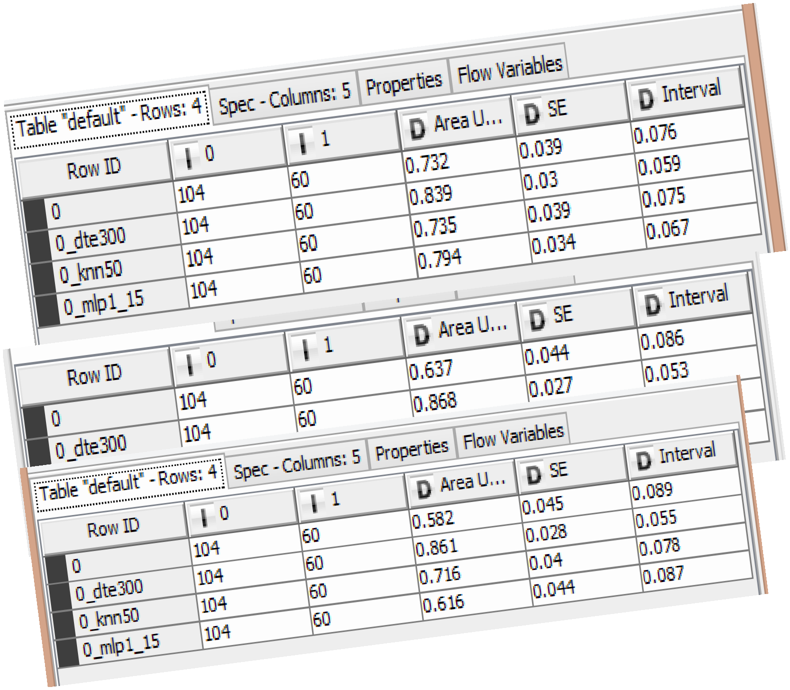


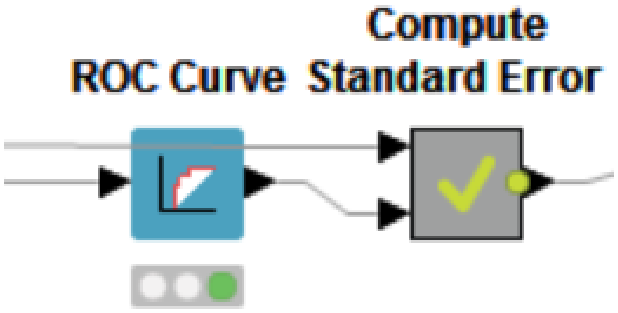
Table "default" - Rows: 4 | Spec - Columns: 5 | Properties | Flow Variables

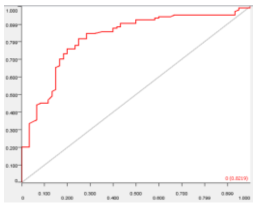
Row ID	I 0	I 1	D Area U...	D SE	D Interval
0	104	60	0.732	0.039	0.076
0_dte300	104	60	0.839	0.03	0.059
0_knn50	104	60	0.735	0.039	0.075
0_mlp1_15	104	60	0.794	0.034	0.067

Row ID	I 0	I 1	D Area U...	D SE	D Interval
0	104	60	0.637	0.044	0.086
0_dte300	104	60	0.868	0.027	0.053

Table "default" - Rows: 4 | Spec - Columns: 5 | Properties | Flow Variables

Row ID	I 0	I 1	D Area U...	D SE	D Interval
0	104	60	0.582	0.045	0.089
0_dte300	104	60	0.861	0.028	0.055
0_knn50	104	60	0.716	0.04	0.078
0_mlp1_15	104	60	0.616	0.044	0.087



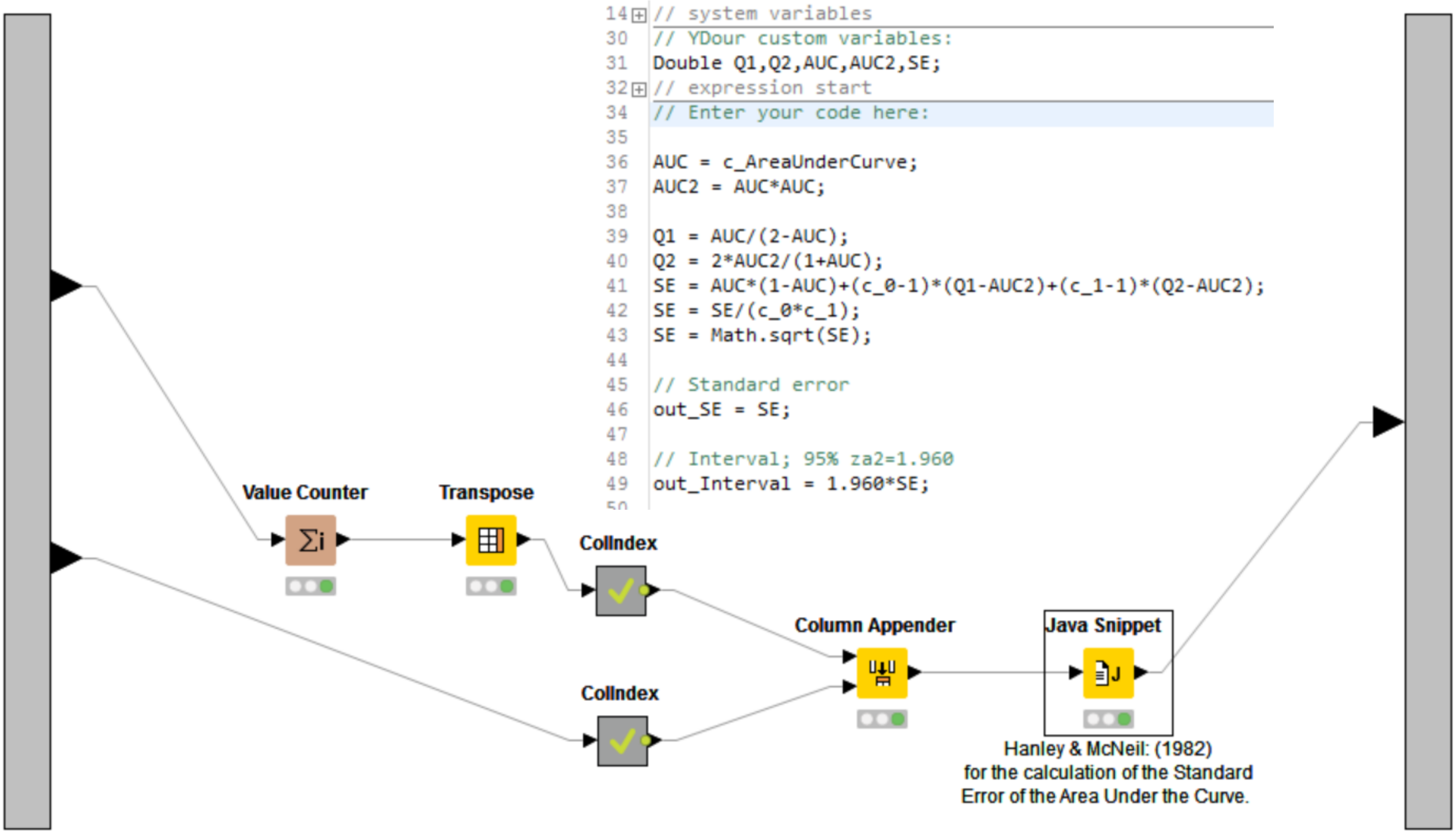


Preprocessing	Predictor	AUC	precision
FFT 8 coefficients	Decision Tree Ensemble	0.84	±0.03
	Mulltilayer Perceptron	0.79	±0.03
Wavelets Haare	Decision Tree Ensemble	0.87	±0.03
	K Nearest Neibourghs	0.75	±0.04
Daubechie 128 coefficients	Decision Tree Ensemble	0.86	±0.03
	K Nearest Neibourghs	0.73	±0.04

Full dataset: **500 soft falls and 1500 normal activities**

Stratified Subset of 20% of the original data

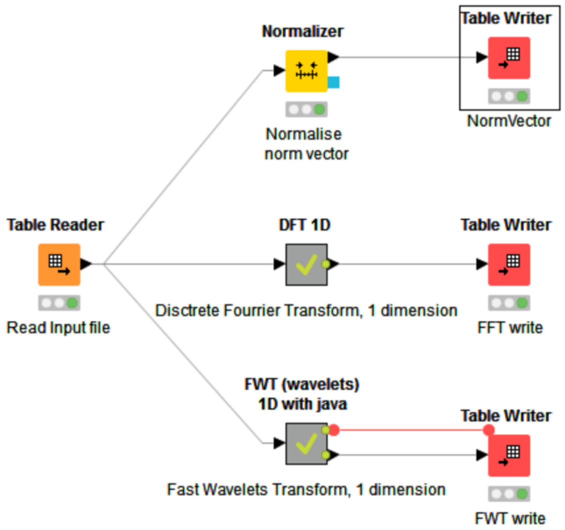
Scoring and precision of AUC

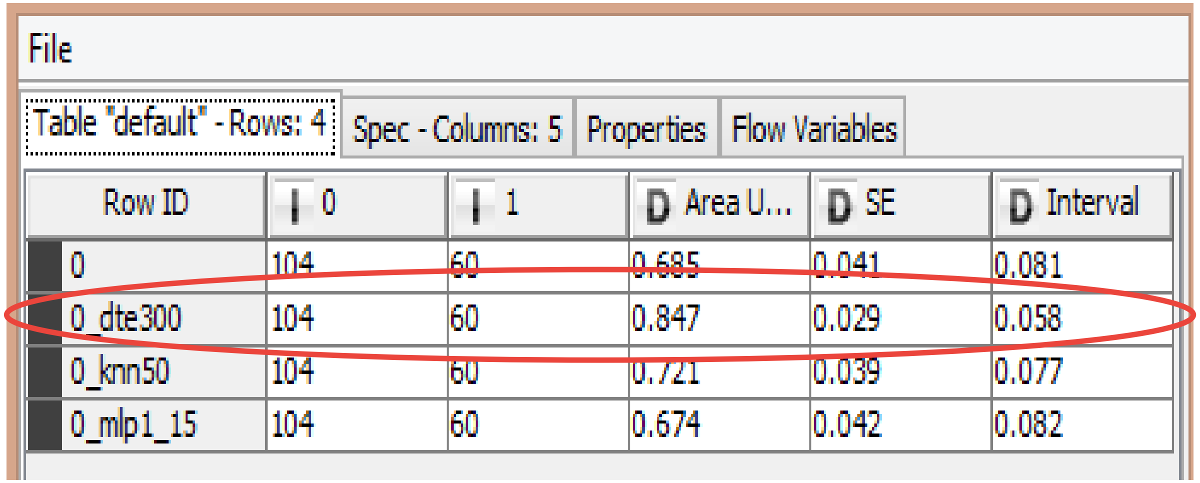


```
// system variables
// YDour custom variables:
Double Q1,Q2,AUC,AUC2,SE;
// expression start
// Enter your code here:

AUC = c_AreaUnderCurve;
AUC2 = AUC*AUC;

Q1 = AUC/(2-AUC);
Q2 = 2*AUC2/(1+AUC);
SE = AUC*(1-AUC)+(c_0-1)*(Q1-AUC2)+(c_1-1)*(Q2-AUC2);
SE = SE/(c_0*c_1);
SE = Math.sqrt(SE);

// Standard error
out_SE = SE;

// Interval; 95% za2=1.960
out_Interval = 1.960*SE;
```

Hanley & McNeil: (1982)
for the calculation of the Standard
Error of the Area Under the Curve.

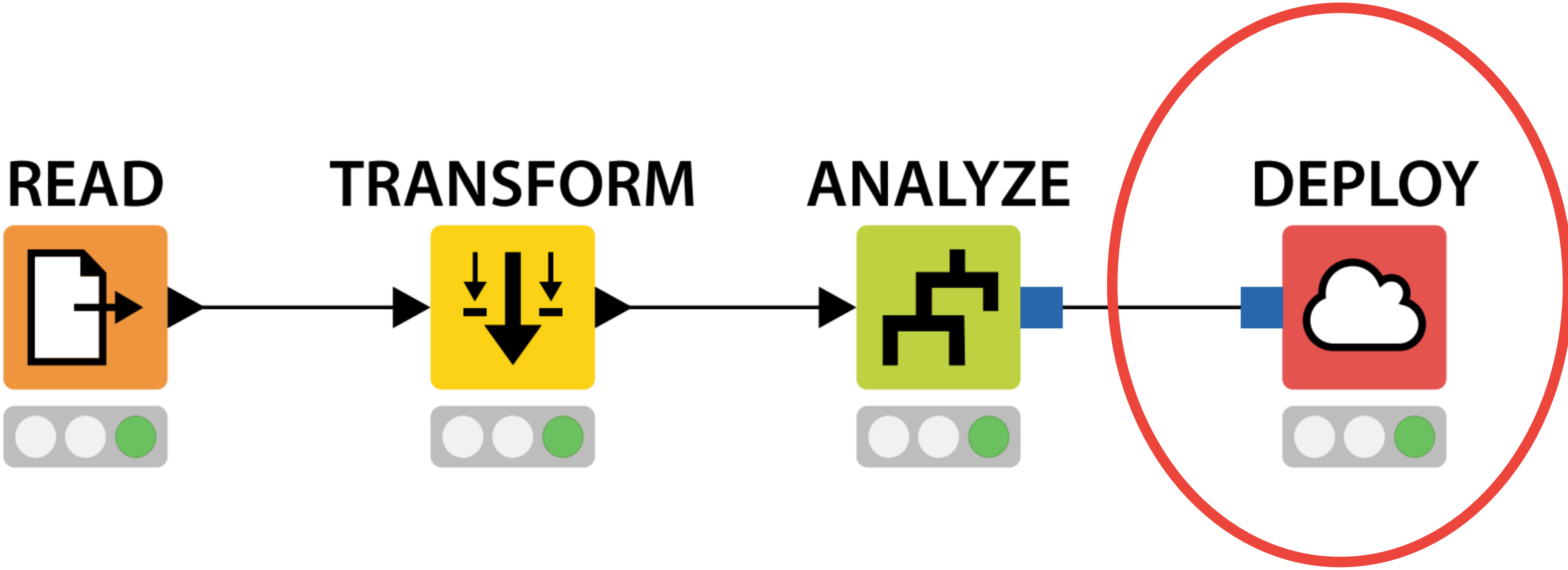
How good are the Decision Tree Ensemble





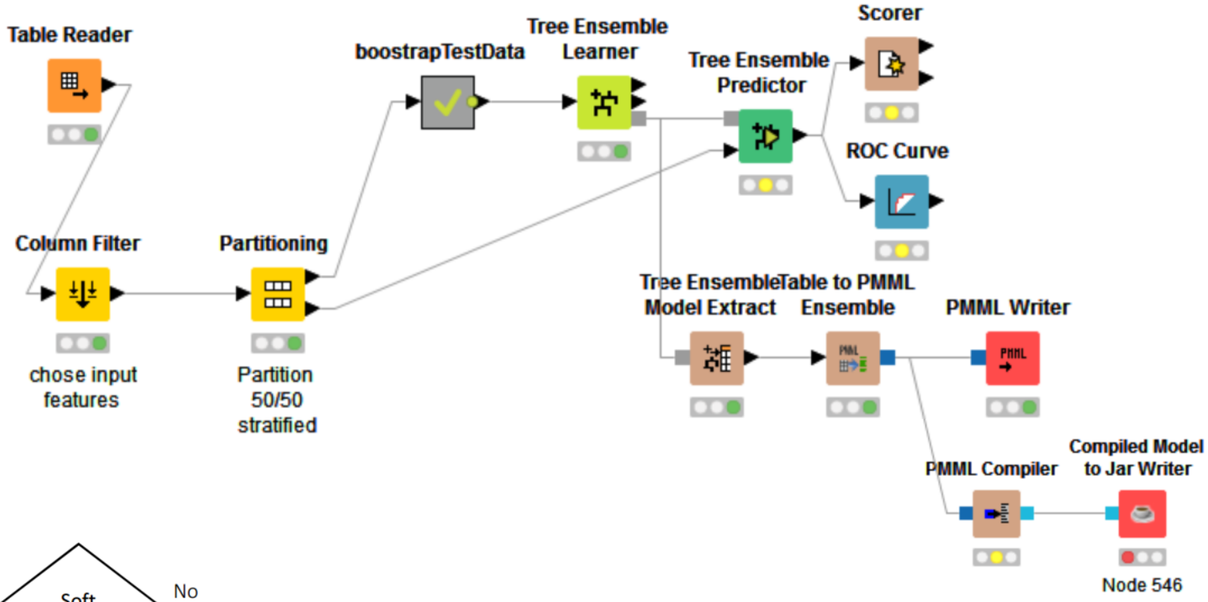
Row ID	I 0	I 1	D Area U...	D SE	D Interval
0	104	60	0.685	0.041	0.081
0_dte300	104	60	0.847	0.029	0.058
0_knn50	104	60	0.721	0.039	0.077
0_mlp1_15	104	60	0.674	0.042	0.082

Processing flow

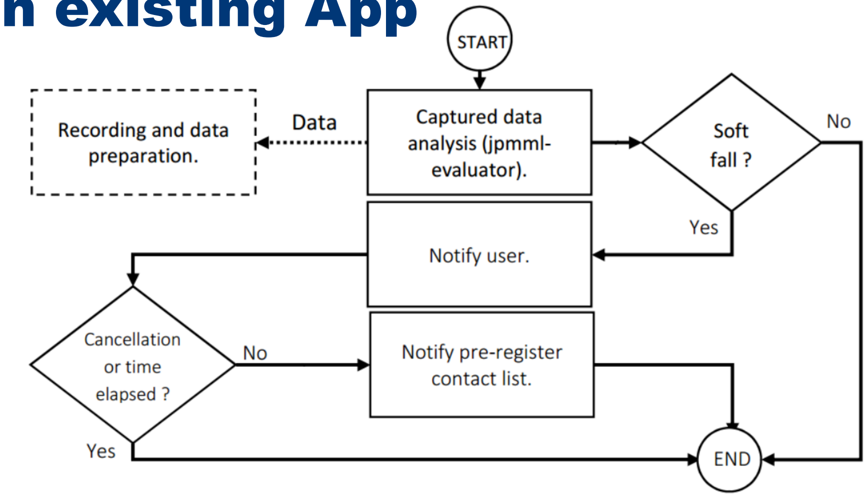


Implementation on Android

Jpmml - open source library



On existing App



START

Captured data analysis (jpmml-evaluator).

Data

Recording and data preparation.

Soft fall ?

No

Yes

Notify user.

Cancellation or time elapsed ?

No

Notify pre-register contact list.

Yes

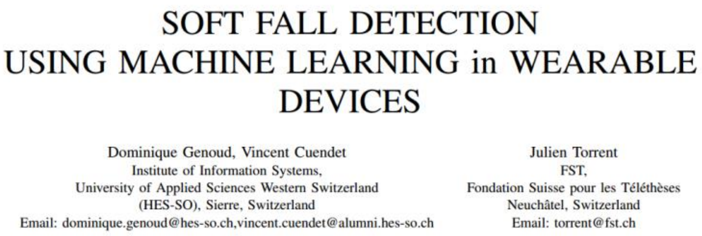
END

Enhancements

- Pmml to java compiler
- Wrapped nodes
- Optimize the size of the pmml in memory

References

- The example workflows will be available
- Paper on soft falls



SOFT FALL DETECTION
USING MACHINE LEARNING in WEARABLE
DEVICES

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The 30th IEEE International Conference on
Advanced Information Networking and Applications (AINA-2016)
Le Régent Congress Centre, Crans-Montana, Switzerland,
March 23-25, 2016

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THEN IT SAYS, "HA HA, THAT WASN'T PUDDING!"