

BFilt

1.1

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Chapter 1

Main Page

1.1 Description

BFilt is a multi-platform and open-source C++ bayesian filtering library. It contains useful and classical algorithms in state estimation of hidden markov models. So you can easily construct discrete-discrete (DD) and continuous-discrete (CD) models (linear or nonlinear) for filtering (Kalman, EKF, UKF, particle filters, ...) and simulation methods. Indeed, markovian model simulators can be used for particle filters. Libraries such as BFL and Bayes++ consider only discrete-discrete filtering. With BFilt, you can easily construct your own CD or DD models for filtering. For CD models stochastic discretization methods (Euler, Runge Kutta, Local linearization, Heun) are implemented in simulation and filtering.

1.2 Dependances

LAPACK and CPPLAPACK libraries are used for linear algebra operations. For best performances it is recommended to compile yourself the LAPPACK libraries with ATLAS. The Gnu Scientific Library (GSL) achieves random drawing in simulators. These open-source and multi-platform libraries must be installed before install BFilt.

1.3 Installation

Go to the bin directory

```
cd BFilt/bin
```

Run Cmake (>2.6)

```
cmake ../src
```

Compile Bfilt

```
make
```

Install BFilt in /usr/local/lib or /usr/local/include

```
make install
```

If you want to change the default install directory you can type

```
ccmake
```

and change CMAKE_INSTALL_PREFIX

1.4 Auteur

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Fri Sep 12 18:34:36 2008

Chapter 2

An AR process

This is an example on the following auto regressive (AR) process :

$$X_k = 0.8X_{k-1} + W_k$$

where, $X_k \in \mathcal{R}$, $W_k \sim \mathcal{N}(0, 0.1)$

This state is then observed by the output $Y_k \in \mathcal{R}$:

$$Y_k = X_k + V_k$$

where $V_k \sim \mathcal{N}(0, 1)$

2.1 Define the AR model

First the ar process must be define as a sister class of [Gaussian_Linear_Model](#).

```
#ifndef __AR_PROCESS
#define __AR_PROCESS

#include <bfilt/gaussian_model.h>

class AR_Process : public Gaussian_Linear_Model
{
public :
    AR_Process(void);
};

#endif
```

The Gaussian Linear [Model](#) are implemented in the following form :

$$X_k = FX_{k-1} + f + GW_k$$

$$Y_k = HX_{k-1} + h + V_k$$

The constructor of AR_Process is then :

```
#include "ar_process.h"

AR_Process::AR_Process(void)
{
    // State Equation
    F.resize(1,1);
    F(0,0) = 0.8;

    f.resize(1);
    f(0) = 0.;

    G.resize(1,1);
    G.identity();

    Qw.resize(1);
    Qw(0,0)= 0.1;

    // Observation noise
    H.resize(1,1);
```

```

    H(0,0) = 1;

    h.resize(1);
    h(0) = 0.;

    Qv.resize(1);
    Qv(0,0)=1;

    // Init state
    X0.resize(1);
    X0(0) = 10.;

    R0.resize(1);
    R0.zero();
}

```

2.2 The main program

In the main program, the model will be first simulated with a specific simulator for gaussian model ([G_Simulator](#)). Then the simulated output sequence $y_{0:N}$ is given to the input of a discrete-discrete kalman filter (DD_Filter) to estimate the state $\hat{X}_{0:k}$. First, all this objects are declared :

```

int main(int argc, char **argv)
{
    AR_Process model;           // The AR model

    G_Simulator sim(&model);     // The simulator

    DD_Kalman filter(&model);    // The Kalman filter
}

```

Then 100 samples are simulated :

```
sim.Simulate(100);
```

The kalman filter is apply on the output sequence :

You can save the simulated sequences :

```

sim.Save_Y("output.dat");
sim.Save_X("state.dat");

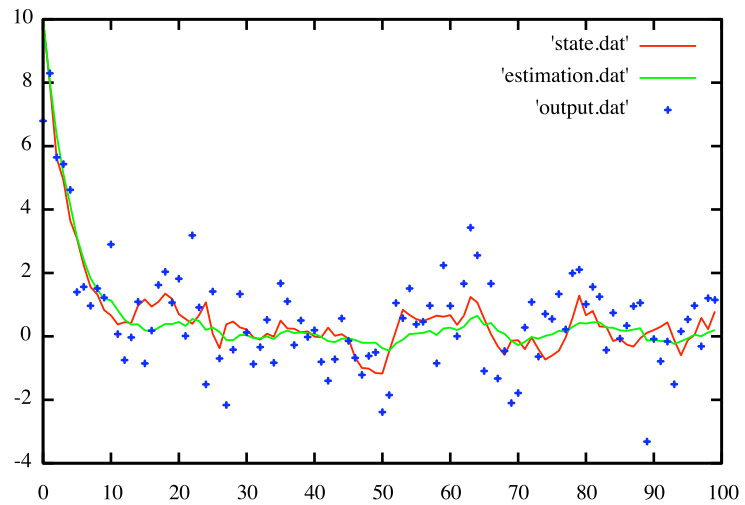
```

and the estimated state :

```
filter.Save_X("estimation.dat");
```

After compiling and execution, with Gnuplot you can plot :

```
plot 'state.dat' w l, 'estimation.dat' w l, 'output.dat'
```



To obtain the following graph :

2.3 The CMakeList.txt

```
CMAKE_MINIMUM_REQUIRED (VERSION 2.6)

PROJECT (Van_Der_Pol)
ADD_DEFINITIONS (" -O3")

# GSL
SET(BFILT_LIB bfilt)

# Include et Link Directories

IF (APPLE)
    MESSAGE("-- Apple Configuration")
    INCLUDE_DIRECTORIES (
        /sw/include/
    )
ENDIF (APPLE)

# Executables and "stand-alone " librairies
ADD_EXECUTABLE (Van_Der_Pol
    van_der_pol.cpp
    example_3.cpp
)

# Linkage
TARGET_LINK_LIBRARIES (Van_Der_Pol
    ${BFILT_LIB}
)
```

Chapter 3

An Ornstein-Uhlenbeck process

This example illustrate how to use BFilt for continuous-discrete filtering. Here the state is described by the following linear stochastic differential equation :

$$d \begin{pmatrix} x \\ \dot{x} \end{pmatrix} = \begin{pmatrix} 0 & 1 \\ -w_0^2 & -\gamma \end{pmatrix} \begin{pmatrix} x \\ \dot{x} \end{pmatrix} dt + \begin{pmatrix} 0 \\ b \end{pmatrix} dt + \begin{pmatrix} 0 \\ g \end{pmatrix} dW(t)$$

Where $W(t)$ is a Wiener process,

$w_0^2 = 16, \gamma = 2, b = 8, g = 2$ and the initials conditions $X_0 = (0, 0)$ and $R_0 = \text{diag}[0, 3]$.

The state $X(t) = (x, \dot{x})(t)$ is then observed by the output $Y_k \in \mathcal{R}$:

$$Y_k = x(t_k) + V_k$$

at discrete time t_k . The sampling period $T_s = t_{k-1} - t_k = 0.2s$ and $V_k \sim \mathcal{N}(0, 0.001)$. In fact only the position is observed. First this model must be define as a sister class of linear time invariant continuous discrete models ([Linear_CD_Model](#)).

```
#ifndef __ORNSTEIN_UHL__
#define __ORNSTEIN_UHL__

#include <bfilt/gaussian_model.h>

class Ornstein_Uhlenbeck_Model : public Linear_CD_Model
{
public :
    double gamma;
    double w;
    double b;
    double g;
    Ornstein_Uhlenbeck_Model(void) ;

};

#endif
```

The [Linear_CD_Model](#) are implemented in the following form :

$$dX(t) = AX(t)dt + Bdt + CdW(t)$$

$$Y_k = HX(t_k) + h + V_k$$

The constructor of Ornstein_Uhlenbeck_Model is then :

```
#include "ornstein_uhlenbeck.h"

Ornstein_Uhlenbeck_Model::Ornstein_Uhlenbeck_Model(void)
{
    // parameters
    w = 4.;
    gamma = 2.;
    b = 8.;
    g = 2.;

    // Matrices of the state equation
    A.resize(2,2);
    A(0,0) = 0.;
    A(0,1) = 1.;
    A(1,0) = - (w*w);
    A(1,1) = -gamma;
```



```

    B.resize(2);
    B(0) = 0;
    B(1) = b;

    C.resize(2,1);
    C(0,0)=0.;
    C(1,0)=g;

    // Matrices of the Observation equation
    H.resize(1,2);
    H(0,0) = 1.;
    H(0,1) = 0.;

    h.resize(2);
    h.zero();

    Qw.resize(1);
    Qw.identity();
    Qw*=0.01;

    Qv.resize(1);
    Qv(0,0) = 0.001;

    // Sampling period
    Ts = 0.2;

    // Initial conditions
    R0.resize(2);
    R0.zero();
    R0(0,0)=0.;
    R0(1,1)=3.;

    X0.resize(2);
    X0.zero();

}

```

3.1 The main program

In the main program, the model will be first simulated with a specific simulator for [Linear_CD_Model \(LTI_CD_Simulator\)](#). The simulated output sequence $y_{0:N}$ is given to the input of the continuous-discrete kalman filter ([CD_Filter](#)) to estimate the state trajectory $\hat{X}_{0:k}$. First, all this objects are declared :

```

int main(int argc, char **argv)
{
    Ornstein_Uhlenbeck_Model model; // The model

    LTI_CD_Simulator sim(&model);    // The simulator

    CD_Kalman filter(&model);        // The Kalman filter

```

Then 10 second are simulated :

```

    sim.Simulate(10.);

```

The kalman filter is apply on the output sequence :

You can save the simulated sequences :

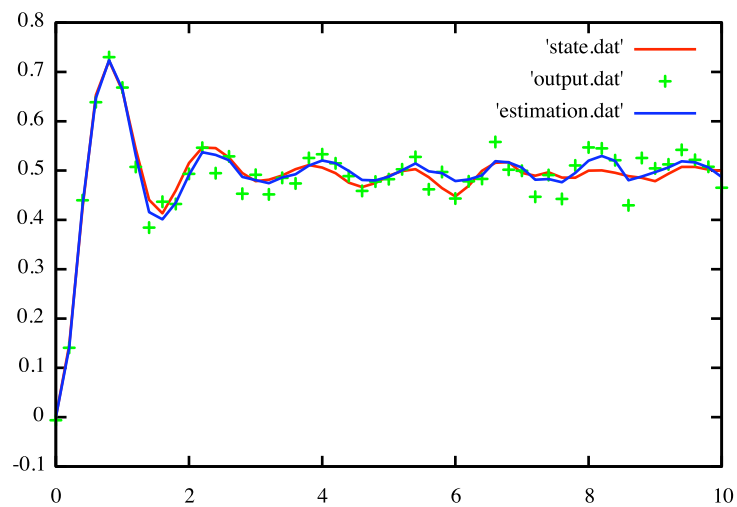
```
sim.Save_Y("output.dat");
sim.Save_X("state.dat");
```

and the estimated state :

```
filter.Save_X("estimation.dat");
```

After compiling and execution, with Gnuplot you can plot :

```
plot 'state.dat' w l, 'estimation.dat' w l, 'output.dat'
```



To obtain the following graph :

3.2 The CMakeList.txt

```
CMAKE_MINIMUM_REQUIRED(VERSION 2.6)

PROJECT(Van_Der_Pol)
ADD_DEFINITIONS(" -O3")

# GSL
SET(BFILT_LIB bfilt)

# Include et Link Directories

IF(APPLE)
  MESSAGE("-- Apple Configuration")
  INCLUDE_DIRECTORIES(
    /sw/include/
  )
ENDIF(APPLE)

# Executables and "stand-alone " librairies
ADD_EXECUTABLE (Van_Der_Pol
  van_der_pol.cpp
  example_3.cpp
)
```

```
# Linkage
TARGET_LINK_LIBRARIES (Van_Der_Pol
    ${BFILT_LIB}
)
```


Chapter 4

Van Der Pol oscillator

This example on the Van der Pol oscillator shows how to use BFilt for non-linear continuous-discrete model. Here the `van_der_pol` class :

van_der_pol.h

```
#ifndef __VAN_DER_POL
#define __VAN_DER_POL

#include <bfilt/gaussian_model.h>

class Van_Der_Pol : public Continuous_Discrete_Model
{
public :
    double lambda;

    Van_Der_Pol(void);
    dcovector Drift_Function(const dcovector & X);
    dgematrix J_Drift_Function(const dcovector & X);
    dcovector Observation_Function(const dcovector& X);
    dgematrix J_Observation_Function(const dcovector & X);
    dgematrix Diffusion_Function(void);
};

#endif
```

van_der_pol.cpp

```
#include "van_der_pol.h"

Van_Der_Pol::Van_Der_Pol(void)
{
    lambda = 3.;

    Qw.resize(1);
    Qw(0,0)= 1.;
    Qv.resize(1);
    Qv(0,0)=0.1;

    X0.resize(2);
    X0(0) = 0.5;
    X0(1) = 0.5;
    R0.resize(2);
    R0.zero();
    R0(0,0)=0.;
    R0(1,1)=.1;
    Ts=.1;
}

dcovector Van_Der_Pol::Drift_Function(const dcovector & X)
{
    dcovector dX(X.1);

    dX(0) = X(1);
    dX(1) = lambda * (1. - X(0) * X(0)) * X(1) - X(0);

    return dX;
}

dgematrix Van_Der_Pol::J_Drift_Function(const dcovector & X)
{
    dgematrix F(X.1,X.1);
```

```

        F(0,0) = 0.;
        F(0,1) = 1.;
        F(1,0) = -2. * lambda * X(0) * X(1);
        F(1,1) = - lambda * X(0) * X(0);

        return F;
    }
    dcovector Van_Der_Pol::Observation_Function(const dcovector& X)
    {
        dcovector Y(1);
        Y(0) = X(0);
        return Y;
    }

    dgematrix Van_Der_Pol::J_Observation_Function(const dcovector & X)
    {
        dgematrix H(1,2);
        H(0,0) = 0.;
        H(0,1) = 1.;
        return H;
    }
    dgematrix Van_Der_Pol::Diffusion_Function(void)
    {
        dgematrix G(2,1);
        G(0,0) = 0.;
        G(1,0) = 1.;

        return G;
    }
}

```

The main program :

```

#include <bfilt/simulator.h>
#include <bfilt/extended_kalman_filter.h>
#include "van_der_pol.h"

int main(int argc, char **argv)
{
    Van_Der_Pol model;                // The model

    CD_Simulator sim(&model);         // The simulator

    CD_Extended_Kalman_Filter filter(&model, THGL);    // The filter

    // Simulation 40 seconds
    sim.Simulate(40.);

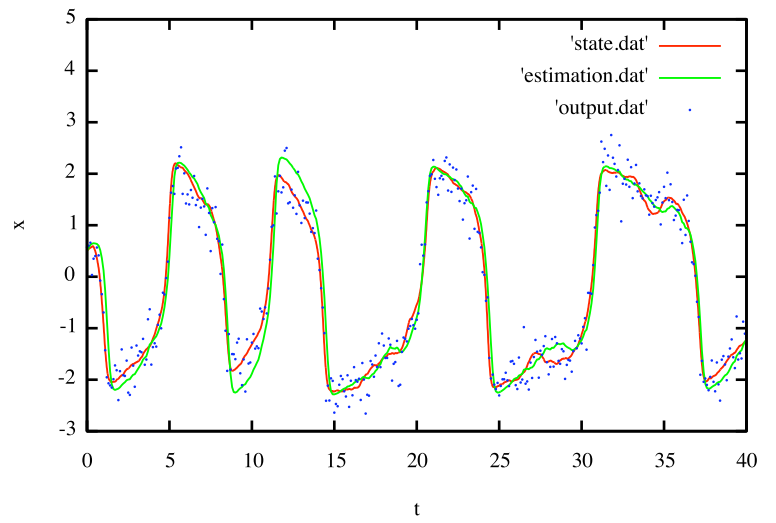
    // Filtering from the simulated output sim.Y
    filter.Filtering(sim.Y);

    // Output Files for simulation
    sim.Save_Y("output.dat");
    sim.Save_X("state.dat");

    // Output File for filtering
    filter.Save_X("estimation.dat");

    return 0;
}

```

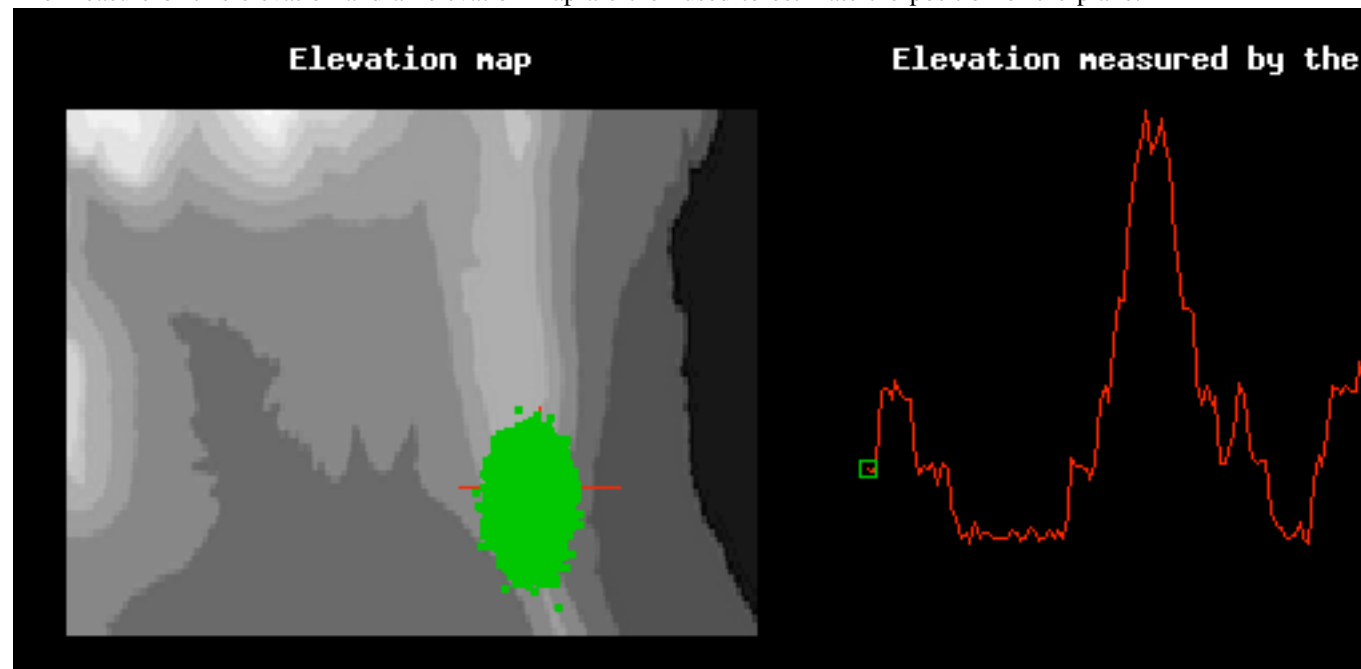


Results can be plotted (here with gnuplot):

Chapter 5

Terrain navigation

This example illustrates the performance of a particle filter compared to a highly non-linear filter. The problem here involves a plane whose trajectory is a brownian motion. This aircraft measures the elevation. The measure of this elevation and an elevation map are then used to estimate the position of the plane.



plane.h

```
#ifndef __PLANE
#define __PLANE

#include <bfilt/gaussian_model.h>

class Plane : public Gaussian_Nonlinear_Model
{
    vector<double> Map;
    double xmin;
    double xmax;
    double ymin;
    double ymax;

    double sigv;
    double sigc;
public :
    Plane(const char *filename);

    dcovector State_Function(const dcovector &X, const dcovector &W);
    dcovector Observation_Function(const dcovector & X);
};

#endif
```

plane.cpp

```
#include "plane.h"

Plane::Plane(const char * filename)
{
```

```

int x,y,z;
ifstream file(filename);

if(file)
{
    file>>xmax;
    file>>ymin;
    file>>z;
    Map.push_back(z);

    while(!file.eof())
    {
        file>>x;
        file>>y;
        file>>z;
        Map.push_back(z);

        if(x>xmax)
            xmax=x;
        if(x<xmin)
            xmin=x;
        if(y>ymin)
            ymin=y;
        if(y<ymin)
            ymax=y;
    }
    file.close();
}
else
{
    cout<<"Plane :: error file"<<endl;
}

Qw.resize(2);
Qw.identity();
Qv.resize(1);
Qv.identity();
Qv*=5.;
R0.resize(4);
R0.zero();
R0(0,0)=10.;
R0(1,1)=10.;
R0(2,2) = .001;
R0(3,3) = 0.0001;
X0.resize(4);
X0(0)=120.;
X0(1)=20.;
X0(2)=1.5;
X0(3)=2.35;

sigv = .001;
sigc = 0.03;
}

dcovector Plane::State_Function(const dcovector &X, const dcovector &W)
{
    dcovector U(4);

    U(0) = X(0) + X(2) * cos(X(3));
    U(1) = X(1) + X(2) * sin(X(3));
    U(2) = X(2) + sigv * W(0);
    U(3) = X(3) + sigc * W(1);
    if (U(0)>xmax)
    {

```

```

        U(0)=xmax;
        U(3)=3.14-U(3);
    }
    if (U(1)>ymax)
    {
        U(1)=ymax;
        U(3)=-U(3);
    }
    if (U(0)<xmin)
    {
        U(0)=xmin;
        U(3)=3.14-U(3);
    }
    if (U(1)<ymin)
    {
        U(1)=ymin;
        U(3)=-U(3);
    }

    return U;
}
dcovector Plane::Observation_Function(const dcovector & X)
{
    int x = (int)(X(0));
    int y = (int)(X(1));
    int j= (xmax+1)*y + x;
    dcovector Y(1);
    Y(0)=Map[j];
    return Y;
}

```

The main program :

```

#include <bfilt/simulator.h>
#include <bfilt/sirs_filter.h>
#include "plane.h"

// This example illustrate performances of particle filter to highly non-linear
// filter. The problem here involves a plane whose the trajectory is a brownian
// motion. This aircraft measure the elevation. The measure of this elevation and
// an elevation map are then used to estimate the position of the plane.
int main(int argc, char **argv)
{
    int k;
    int i;
    int j;
    vector<Weighted_Sample> cloud;

    ofstream file_c("../data/cloud.dat"); // To save the cloud
    ofstream file_s("../data/state.dat"); // To save the state

    Plane plane("../data/map_2.dat"); // The plane model
    G_Simulator sim(&plane); // To simulate a this model

    Bootstrap_Filter filter(100000,&plane); // A bootstrap filter to estimate the position

    sim.Simulate(150); // simulation of 250 samples

    sim.Save_Y("../data/output.dat"); // save the output

    // Here Init() and Update methods are used
    // for filtering because we want to get the cloud
    // at each step and save it in cloud.dat

    filter.Init(); // Initialization of the bootstrap filter

```

```
for (k=0; k<sim.Y.size(); k++)
{
    cloud=filter.CloudGet();           // The current cloud is return
    for(i=0; i<cloud.size(); i++)      // and here it is saved
    {
        for(j=0; j<cloud[i].Value.l; j++)
            file_c<<cloud[i].Value(j)<<" ";
        file_c<<endl;
    }

    for (j=0; j<sim.X[k].l; j++)       // The state is also saved
        file_s<<sim.X[k](j)<<" ";
    file_s<<endl<<endl<<endl;
    file_c<<endl<<endl;

    if( filter.Update(sim.Y[k]))       // The filter is then update with a new observ
        filter.Init();
    }
    file_c.close();
    file_s.close();

    return 0;
}
```


Chapter 6

Class Index

6.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

Filter	62
CD_Filter	35
CD_Extended_Kalman_Filter	33
CD_Kalman	38
LL_Filter	85
THGL_Filter	111
GA_Filter	71
DD_Kalman	49
Extended_Kalman_Filter	61
Unscented_Kalman_Filter	112
SISR_Filter	105
Bootstrap_Filter	27
CD_Bootstrap_Filter	31
OptSISR_Filter	95
Model	89
Discrete_Observed_Model	56
Continuous_Discrete_Model	46
Linear_CD_Model	82
Gaussian_Nonlinear_Model	77
Discrete_Approximation_CD_Model	51
Euler_CD_Model	59
Heun_CD_Model	80
Ozaki_CD_Model	96
SRK4_CD_Model	109
Gaussian_Linear_Model	74
SI_Sampler	98
Bootstrap_Sampler	29
Optimal_Sampler	93
Simulator	101
CD_Simulator	40
CD_Simulator_WT	44

LTI_CD_Simulator	86
LTI_CD_Simulator_WT	87
Opt_Simulator	91
G_Simulator	66
G_Simulator_WT	69
Weighted_Sample	116

Chapter 7

Class Index

7.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Bootstrap_Filter	27
Bootstrap_Sampler (This sampler use the transition as importance density)	29
CD_Bootstrap_Filter	31
CD_Extended_Kalman_Filter	33
CD_Filter (Abstract class of continuous-discrete filters)	35
CD_Kalman (The continuous-discrete kalman filter)	38
CD_Simulator	40
CD_Simulator_WT	44
Continuous_Discrete_Model (Continuous Discrete Model : The continuous state : $dX(t) = F(X)dt + G() * d\beta$ The discrete Observation $Y_k = H(X(tk)) + V_k$)	46
DD_Kalman (The discrete-discrete kalman filter)	49
Discrete_Approximation_CD_Model (Continuous state equation is discretely approximate by $X(tk) = f'(X(tk-1), W_k)$)	51
Discrete_Observed_Model (Class of discretely observed model)	56
Euler_CD_Model (Continuous discret model: the state SDE is discretely approximate by an Euler method)	59
Extended_Kalman_Filter	61
Filter (Abstract class of all filters)	62
G_Simulator	66
G_Simulator_WT	69
GA_Filter (Abstract class of Gaussian Approximation filters)	71
Gaussian_Linear_Model (Gaussian Linear Model :)	74
Gaussian_Nonlinear_Model (Gaussian Nonlinear Model The state : $X(k) = F(X_{k-1}, W_k)$ The Observation $Y(k) = H(X(k)) + V$)	77
Heun_CD_Model (Continuous discret model: the state SDE is discretely approximate by an Sstochastic Heun method)	80
Linear_CD_Model (Linear continuous discrete model class of the form $dx = AX dt + Bdt + CdW$ $Y_k = HX(t_k) + h + V_k$)	82
LL_Filter	85
LTI_CD_Simulator	86
LTI_CD_Simulator_WT	87
Model (The class of time varying-models)	89
Opt_Simulator	91

Optimal_Sampler (This sampler use the optimal importance density)	93
OptSISR_Filter	95
Ozaki_CD_Model (Continuous discret model: the state SDE is discretly approximate by Ozaki method)	96
SI_Sampler (Sequential importance sampler used for sisr filter (bootstrap,optimal ...))	98
Simulator	101
SISR_Filter	105
SRK4_CD_Model (Continuous discret model: the state SDE is discretly approximate by an Sstochastic runge kutta method)	109
THGL_Filter	111
Unscented_Kalman_Filter (The Discrete Unscented Kalman Filter (UKF))	112
Weighted_Sample	116

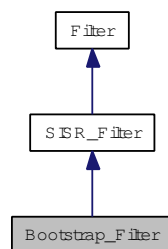
Chapter 8

Class Documentation

8.1 Bootstrap_Filter Class Reference

```
#include <sisr_filter.h>
```

Inheritance diagram for Bootstrap_Filter:



Public Member Functions

- [Bootstrap_Filter](#) (void)
- [~Bootstrap_Filter](#) (void)
- [Bootstrap_Filter](#) (const int &Ns, [Simulator](#) *s)
- [Bootstrap_Filter](#) (const int &Ns, [Gaussian_Nonlinear_Model](#) *m)

Private Attributes

- [Simulator](#) * [sim](#)

8.1.1 Constructor & Destructor Documentation

8.1.1.1 `Bootstrap_Filter::Bootstrap_Filter (void)`

8.1.1.2 `Bootstrap_Filter::~~Bootstrap_Filter (void)`

8.1.1.3 `Bootstrap_Filter::Bootstrap_Filter (const int & Ns, Simulator * s)`

8.1.1.4 `Bootstrap_Filter::Bootstrap_Filter (const int & Ns, Gaussian_Nonlinear_Model * m)`

8.1.2 Member Data Documentation

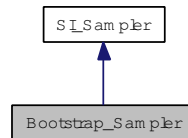
8.1.2.1 `Simulator* Bootstrap_Filter::sim` [private]

8.2 Bootstrap_Sampler Class Reference

This sampler use the transition as importance density.

```
#include <sisr_filter.h>
```

Inheritance diagram for Bootstrap_Sampler:



Public Member Functions

- [Bootstrap_Sampler](#) (void)
- [Bootstrap_Sampler](#) ([Simulator](#) *m)
- [vector< Weighted_Sample > DrawInitCloud](#) (const int &NbSample)
draw a set of possible init state
- [vector< Weighted_Sample > Draw](#) (const [dcovector](#) &Y_k, const [vector< Weighted_Sample >](#) &X_km1)
Draw a set of samples from the importance density Xk given Y0:k X0:k-1.
- [long double Weight](#) ([vector< Weighted_Sample >](#) &cloud, const [dcovector](#) &Y_k, const [vector< Weighted_Sample >](#) &X_k)
Modify the weights of cloud for the weighting step in the sisr.

8.2.1 Detailed Description

This sampler use the transition as importance density.

8.2.2 Constructor & Destructor Documentation

8.2.2.1 Bootstrap_Sampler::Bootstrap_Sampler (void)

8.2.2.2 Bootstrap_Sampler::Bootstrap_Sampler (Simulator * m)

8.2.3 Member Function Documentation

8.2.3.1 [vector<Weighted_Sample > Bootstrap_Sampler::Draw](#) (const [dcovector](#) & Y_k, const [vector< Weighted_Sample >](#) & X_km1) [virtual]

Draw a set of samples from the importance density Xk given Y0:k X0:k-1.

Parameters:

Y_k The observation from 0 to k

X_km1 The cloud from 0 to km1

Returns:

A cloud representing the importance density $q(X_k|Y_{0:k}, X_{0:k-1})$

Implements [SI_Sampler](#).

8.2.3.2 `vector<Weighted_Sample> Bootstrap_Sampler::DrawInitCloud (const int & NbSample)`
[virtual]

draw a set of possible init state

Parameters:

NbSample Number of sample

Returns:

A set of weighted samples

Implements [SI_Sampler](#).

8.2.3.3 `long double Bootstrap_Sampler::Weight (vector< Weighted_Sample> & cloud, const dcovector & Y_k, const vector< Weighted_Sample> & X_km1)` [virtual]

Modify the weights of cloud for the weighting step in the sirs.

Parameters:

cloud The curent coud at k

Y_k The observation at k

X_km1 the cloud from at km1

Returns:

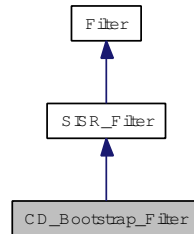
The sum of the weights

Implements [SI_Sampler](#).

8.3 CD_Bootstrap_Filter Class Reference

```
#include <sisr_filter.h>
```

Inheritance diagram for CD_Bootstrap_Filter:



Public Member Functions

- [CD_Bootstrap_Filter](#) (void)
- [~CD_Bootstrap_Filter](#) (void)
- [CD_Bootstrap_Filter](#) (const int &Ns, [CD_Simulator](#) *s)
- [CD_Bootstrap_Filter](#) (const int &Ns, [Continuous_Discrete_Model](#) *m)
- [CD_Bootstrap_Filter](#) (const int &Ns, [Linear_CD_Model](#) *m)
- virtual int [Save_X](#) (const char *filename)

Private Attributes

- [CD_Simulator](#) * [sim](#)

8.3.1 Constructor & Destructor Documentation

8.3.1.1 [CD_Bootstrap_Filter::CD_Bootstrap_Filter](#) (void)

8.3.1.2 [CD_Bootstrap_Filter::~CD_Bootstrap_Filter](#) (void)

8.3.1.3 [CD_Bootstrap_Filter::CD_Bootstrap_Filter](#) (const int &Ns, [CD_Simulator](#) *s)

8.3.1.4 [CD_Bootstrap_Filter::CD_Bootstrap_Filter](#) (const int &Ns, [Continuous_Discrete_Model](#) *m)

8.3.1.5 [CD_Bootstrap_Filter::CD_Bootstrap_Filter](#) (const int &Ns, [Linear_CD_Model](#) *m)

8.3.2 Member Function Documentation

8.3.2.1 virtual int [CD_Bootstrap_Filter::Save_X](#) (const char **filename*) [virtual]

Save the estimation $\{\hat{X}_{k|k}, k = 0, \dots, N\}$

Parameters:

filename

Returns:

0 if everything is ok

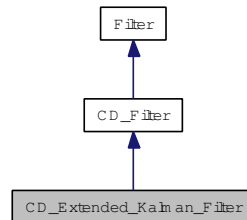
Reimplemented from [Filter](#).

8.3.3 Member Data Documentation**8.3.3.1** `CD_Simulator* CD_Bootstrap_Filter::sim` `[private]`

8.4 CD_Extended_Kalman_Filter Class Reference

```
#include <extended_kalman_filter.h>
```

Inheritance diagram for CD_Extended_Kalman_Filter:



Public Member Functions

- [CD_Extended_Kalman_Filter](#) (void)
- [CD_Extended_Kalman_Filter](#) ([Continuous_Discrete_Model](#) *m, const int &sh=RK4)

Public Attributes

- int [Scheme](#)

Protected Member Functions

- int [_update](#) (const dcovector &Y)
- void [_thgl__prediction](#) (dcovector &M, dgematrix &P)
- void [_euler__prediction](#) (dcovector &M, dgematrix &P)
- void [_rk4__prediction](#) (dcovector &M, dgematrix &P)
- void [_heun__prediction](#) (dcovector &M, dgematrix &P)
- void [_rk4__prediction_FM](#) (dcovector &M, dgematrix &P)

8.4.1 Constructor & Destructor Documentation

8.4.1.1 **CD_Extended_Kalman_Filter::CD_Extended_Kalman_Filter** (void)

8.4.1.2 **CD_Extended_Kalman_Filter::CD_Extended_Kalman_Filter**
(Continuous_Discrete_Model * *m*, const int & *sh* = RK4)

8.4.2 Member Function Documentation

8.4.2.1 **void CD_Extended_Kalman_Filter::_euler_prediction** (dcovector & *M*, dgematrix & *P*)
[protected]

8.4.2.2 **void CD_Extended_Kalman_Filter::_heun__prediction** (dcovector & *M*, dgematrix & *P*)
[protected]

8.4.2.3 **void CD_Extended_Kalman_Filter::_rk4__prediction** (dcovector & *M*, dgematrix & *P*)
[protected]

8.4.2.4 **void CD_Extended_Kalman_Filter::_rk4__prediction_FM** (dcovector & *M*, dgematrix & *P*)
[protected]

8.4.2.5 **void CD_Extended_Kalman_Filter::_thgl__prediction** (dcovector & *M*, dgematrix & *P*)
[protected]

8.4.2.6 **int CD_Extended_Kalman_Filter::_update** (const dcovector & *Y*) [protected, virtual]

Specific update for each filter

Parameters:

Y The observed sample

Returns:

0 if no problem

Implements [Filter](#).

8.4.3 Member Data Documentation

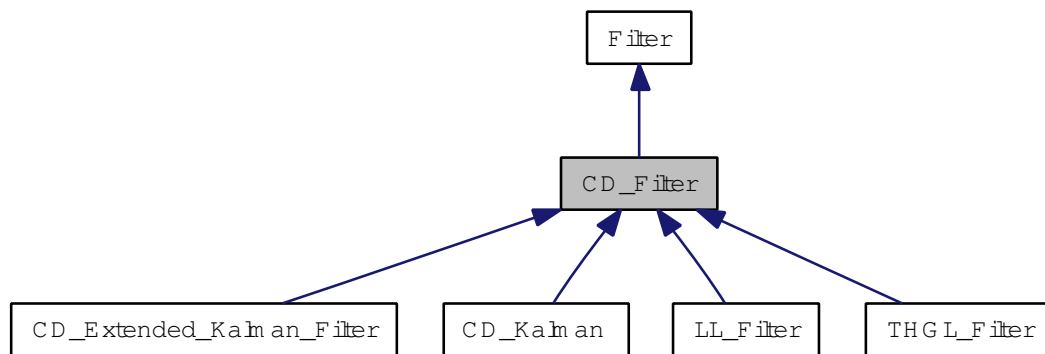
8.4.3.1 **int CD_Extended_Kalman_Filter::Scheme**

8.5 CD_Filter Class Reference

Abstract class of continuous-discrete filters.

```
#include <filter.h>
```

Inheritance diagram for CD_Filter:



Public Member Functions

- [CD_Filter](#) (void)
A constructor.
- [CD_Filter](#) ([Continuous_Discrete_Model](#) *m)
- int [Save_X](#) (const char *filename)
- dcovector [Expected_Get](#) (void)

Public Attributes

- dcovector [M](#)
The current mean $\hat{X}_{k|k} = E[X_k|Y_{0:k}]$.
- dgematrix [R](#)
The current covariance $\hat{P}_{k|k} = E[(X_k - \hat{X}_{k|k})(X_k - \hat{X}_{k|k})]$.
- dcovector [Xp](#)
The prediction $\hat{X}_{k-1|k} = E[X_{k-1}|Y_{0:k}]$.
- dgematrix [Rp](#)
The prediction covariance $\hat{P}_{k-1|k} = E[(X_k - \hat{X}_{k-1|k})(X_k - \hat{X}_{k-1|k})]$.

Protected Member Functions

- int [_init](#) (void)

8.5.1 Detailed Description

Abstract class of continuous-discrete filters.

For continuous-discrete models ([Continuous_Discrete_Model](#)), these filters approximate the probability density of the state transition $p_{X(t_k)|X(t_{k-1})}$ and the probability of the observation $p_{Y_k|X(t_k)}$ by gaussian densities. The approximation is exact in the case of linear continuous-discrete models ([Linear_CD_Model](#)) and lead to the continuous-discrete Kalman [Filter](#) ([CD_Kalman](#)). For other non-linear models ([Continuous_Discrete_Model](#)) Local linearization filter ([LL_Filter](#)) or continuous-discrete [Filter](#) EKF ([CD_Extended_Kalman_Filter](#)) can be used.

8.5.2 Constructor & Destructor Documentation

8.5.2.1 `CD_Filter::CD_Filter (void)`

A constructor.

8.5.2.2 `CD_Filter::CD_Filter (Continuous_Discrete_Model * m)`

A constructor

Parameters:

m A discrete-discrete gaussian non-linear model

8.5.3 Member Function Documentation

8.5.3.1 `int CD_Filter::_init (void)` [`protected`, `virtual`]

Specific init for each filter

Parameters:

Y The observed sample

Returns:

0 if no problem

Implements [Filter](#).

8.5.3.2 `dcovector CD_Filter::Expected_Get (void)` [`virtual`]

Get the current estimation $\hat{X}_{k|k}$

Returns:

$\hat{X}_{k|k}$

Implements [Filter](#).

8.5.3.3 int CD_Filter::Save_X (const char **filename*) [virtual]

Save the estimation $\{\hat{X}_{k|k}, k = 0, \dots, N\}$

Parameters:

filename

Returns:

0 if everything is ok

Reimplemented from [Filter](#).

8.5.4 Member Data Documentation**8.5.4.1 dcovector CD_Filter::M**

The current mean $\hat{X}_{k|k} = E[X_k | Y_{0:k}]$.

8.5.4.2 dgematrix CD_Filter::R

The current covariance $\hat{P}_{k|k} = E[(X_k - \hat{X}_{k|k})(X_k - \hat{X}_{k|k})]$.

8.5.4.3 dgematrix CD_Filter::Rp

The prediction covariance $\hat{P}_{k-1|k} = E[(X_k - \hat{X}_{k-1|k})(X_k - \hat{X}_{k-1|k})]$.

8.5.4.4 dcovector CD_Filter::Xp

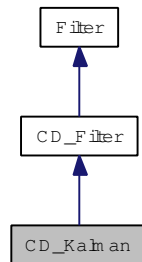
The prediction $\hat{X}_{k-1|k} = E[X_{k-1} | Y_{0:k}]$.

8.6 CD_Kalman Class Reference

The continuous-discrete kalman filter.

```
#include <filter.h>
```

Inheritance diagram for CD_Kalman:



Public Member Functions

- [CD_Kalman](#) (void)
- [CD_Kalman](#) ([Linear_CD_Model](#) *m)

Protected Member Functions

- [int _update](#) (const dcovector &Y)

8.6.1 Detailed Description

The continuous-discrete kalman filter.

Give an exact solution of $\hat{X}_{k|k}$ and $\hat{P}_{k|k}$ for continuous-discrete linear models ([Linear_CD_Model](#)).

8.6.2 Constructor & Destructor Documentation

8.6.2.1 CD_Kalman::CD_Kalman (void)

8.6.2.2 CD_Kalman::CD_Kalman ([Linear_CD_Model](#) * m)

A constructor

Parameters:

m The continuous discrete model

8.6.3 Member Function Documentation

8.6.3.1 int CD_Kalman::_update (const dcovector & Y) [protected, virtual]

Specific update for each filter

Parameters:

Y The observed sample

Returns:

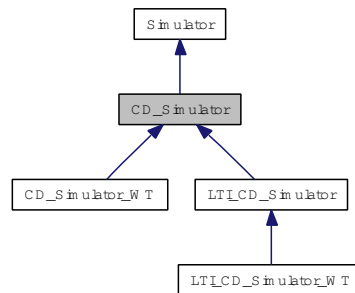
0 if no problem

Implements [Filter](#).

8.7 CD_Simulator Class Reference

```
#include <simulator.h>
```

Inheritance diagram for CD_Simulator:



Public Member Functions

- [CD_Simulator](#) (void)
- [CD_Simulator](#) ([Continuous_Discrete_Model](#) *cd_m, const int &[scheme](#)=SRK4, const int &alpha=10)
- virtual dcovector [Draw_Init](#) (void)
Draw a sample from $p(X_0)$.
- dcovector [Draw_Transition](#) (const dcovector &Xkm1)
Draw a sample from the transition density $p(X_k|X_{k-1})$.
- dcovector [Draw_Observation](#) (const dcovector &Xk)
Calculate the value of the density of probability of Y given X : $p(Y|X)$.
- long double [Observation_Density](#) (const dcovector &Y, const dcovector &X)
calculate the value of the density of probability of Y given X : $p(Y|X)$
- int [Save_X](#) (const char *filename)
Save the simulated state trajectory in filename.
- int [Save_Y](#) (const char *filename)
Save the simulated observation trajectory in filename.
- int [Simulate](#) (const double &T)
- void [Set_Alpha](#) (const int &al)

Public Attributes

- double [Dy](#)
- double [Dx](#)

Protected Member Functions

- virtual dcovector [draw_state](#) (const dcovector &[X](#))
- void [_update](#) (void)

Protected Attributes

- int [scheme](#)
- int [_a](#)

8.7.1 Constructor & Destructor Documentation

8.7.1.1 [CD_Simulator::CD_Simulator](#) (void)

8.7.1.2 [CD_Simulator::CD_Simulator](#) (Continuous_Discrete_Model * *cd_m*, const int & *scheme* = SRK4, const int & *apha* = 10)

8.7.2 Member Function Documentation

8.7.2.1 void [CD_Simulator::_update](#) (void) [protected, virtual]

Reimplemented from [Simulator](#).

8.7.2.2 virtual dcovector [CD_Simulator::Draw_Init](#) (void) [virtual]

Draw a sample from $p(X_0)$.

Returns:

A sample from $p(X_0)$

Implements [Simulator](#).

Reimplemented in [CD_Simulator_WT](#), and [LTI_CD_Simulator_WT](#).

8.7.2.3 dcovector [CD_Simulator::Draw_Observation](#) (const dcovector & *Xk*) [virtual]

Calculate the value of the density of probability of Y given X : $p(Y|X)$.

Parameters:

Xk The state at k

Returns:

The simulated observation

Implements [Simulator](#).

8.7.2.4 virtual dcovector [CD_Simulator::draw_state](#) (const dcovector & *X*) [protected, virtual]

Reimplemented in [LTI_CD_Simulator](#).

8.7.2.5 dcovector CD_Simulator::Draw_Transition (const dcovector & *Xkm1*) [virtual]

Draw a sample from the transition density $p(X_k|X_{k-1})$.

Parameters:

Xkm1 $X(k-1)$ the preceding state

Returns:

Implements [Simulator](#).

8.7.2.6 long double CD_Simulator::Observation_Density (const dcovector & *Y*, const dcovector & *X*) [virtual]

calculate the value of the density of probability of Y given X : $p(Y|X)$

Parameters:

Y The osbervation

X The state

Returns:

The value of the density

Implements [Simulator](#).

8.7.2.7 int CD_Simulator::Save_X (const char **filename*) [virtual]

Save the simulated state trajectory in filename.

Parameters:

filename The file

Returns:

0 if it's ok

Reimplemented from [Simulator](#).

8.7.2.8 int CD_Simulator::Save_Y (const char **filename*) [virtual]

Save the simulated observation trajectory in filename.

Parameters:

filename The file

Returns:

0 if it's ok

Reimplemented from [Simulator](#).

8.7.2.9 void CD_Simulator::Set_Alpha (const int & *al*)

8.7.2.10 int CD_Simulator::Simulate (const double & *T*)

8.7.3 Member Data Documentation

8.7.3.1 int CD_Simulator::_a [protected]

8.7.3.2 double CD_Simulator::Dx

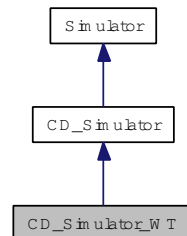
8.7.3.3 double CD_Simulator::Dy

8.7.3.4 int CD_Simulator::scheme [protected]

8.8 CD_Simulator_WT Class Reference

```
#include <simulator.h>
```

Inheritance diagram for CD_Simulator_WT:



Public Member Functions

- [CD_Simulator_WT](#) (void)
- [CD_Simulator_WT](#) ([Continuous_Discrete_Model](#) **cd_m*, const int &*scheme*, const int &*apha*, const double &*tb*, const double &*t*)
- dcovector [Draw_Init](#) (void)
Draw a sample from $p(X_0)$.

Private Attributes

- vector< dcovector > [Xt](#)
- double [TB](#)
- double [T](#)

8.8.1 Constructor & Destructor Documentation

8.8.1.1 CD_Simulator_WT::CD_Simulator_WT (void)

8.8.1.2 CD_Simulator_WT::CD_Simulator_WT ([Continuous_Discrete_Model](#) **cd_m*, const int &*scheme*, const int &*apha*, const double &*tb*, const double &*t*)

8.8.2 Member Function Documentation

8.8.2.1 dcovector CD_Simulator_WT::Draw_Init (void) [virtual]

Draw a sample from $p(X_0)$.

Returns:

A sample from $p(X_0)$

Reimplemented from [CD_Simulator](#).

8.8.3 Member Data Documentation

8.8.3.1 `double CD_Simulator_WT::T` [private]

8.8.3.2 `double CD_Simulator_WT::TB` [private]

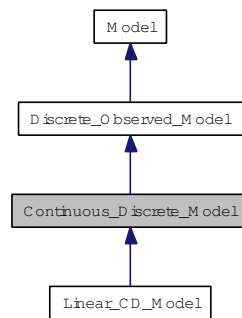
8.8.3.3 `vector<dcovector> CD_Simulator_WT::Xt` [private]

8.9 Continuous_Discrete_Model Class Reference

Continuous Discrete [Model](#): The continuous state : $dX(t) = F(X)dt + G() * d\beta$ The discrete Observation $Y_k = H(X(tk)) + V_k$.

```
#include <gaussian_model.h>
```

Inheritance diagram for Continuous_Discrete_Model:



Public Member Functions

- [Continuous_Discrete_Model](#) (void)
- virtual [~Continuous_Discrete_Model](#) (void)
- virtual dcovector [Drift_Function](#) (const dcovector &X)=0
*the drift function of $dX(t) = F(X)dt + G(X)*dW$*
- virtual dgematrix [J_Drift_Function](#) (const dcovector &X)
the jacobian of the drift function evaluate at X
- virtual dgematrix [Diffusion_Function](#) (void)=0
the diffusion function
- virtual void [Init](#) (void)

Public Attributes

- double [Ts](#)
The sampling periode $T_s = t_k - t_{k-1}$.

8.9.1 Detailed Description

Continuous Discrete [Model](#): The continuous state : $dX(t) = F(X)dt + G() * d\beta$ The discrete Observation $Y_k = H(X(tk)) + V_k$.

8.9.2 Constructor & Destructor Documentation

8.9.2.1 Continuous_Discrete_Model::Continuous_Discrete_Model (void)

The constructor

8.9.2.2 virtual Continuous_Discrete_Model::~~Continuous_Discrete_Model (void) [virtual]

The destructor

8.9.3 Member Function Documentation

8.9.3.1 virtual dgematrix Continuous_Discrete_Model::Diffusion_Function (void) [pure virtual]

the diffusion function

Parameters:

X the state

Returns:

$G(X)$.

Implemented in [Linear_CD_Model](#).

8.9.3.2 virtual dcovector Continuous_Discrete_Model::Drift_Function (const dcovector & X) [pure virtual]

the drift function of $dX(t) = F(X)dt + G(X)*dW$

Parameters:

X the state.

Returns:

$f(X)$

Implemented in [Linear_CD_Model](#).

8.9.3.3 virtual void Continuous_Discrete_Model::Init (void) [inline, virtual]

Initialized CD model

Reimplemented in [Linear_CD_Model](#).

8.9.3.4 virtual dgematrix Continuous_Discrete_Model::J_Drift_Function (const dcovector & X) [virtual]

the jacobian of the drift function evaluate at X

Parameters: X **Returns:**

the jacobian matrix

Reimplemented in [Linear_CD_Model](#).

8.9.4 Member Data Documentation

8.9.4.1 `double Continuous_Discrete_Model::Ts`

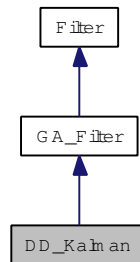
The sampling periode $T_s = t_k - t_{k-1}$.

8.10 DD_Kalman Class Reference

The discrete-discrete kalman filter.

```
#include <filter.h>
```

Inheritance diagram for DD_Kalman:



Public Member Functions

- [DD_Kalman](#) (void)
- [DD_Kalman](#) ([Gaussian_Linear_Model](#) *m)

Protected Member Functions

- [int _update](#) (const dcovector &Y)

8.10.1 Detailed Description

The discrete-discrete kalman filter.

Give an exact solution of $\hat{X}_{k|k}$ and $\hat{P}_{k|k}$ for discrete-discrete linear models ([Gaussian_Linear_Model](#)).

8.10.2 Constructor & Destructor Documentation

8.10.2.1 DD_Kalman::DD_Kalman (void)

8.10.2.2 DD_Kalman::DD_Kalman ([Gaussian_Linear_Model](#) * m)

A constructor

Parameters:

m The discrete-discrete model

8.10.3 Member Function Documentation

8.10.3.1 int DD_Kalman::_update (const dcovector & Y) [protected, virtual]

Specific update for each filter

Parameters:

Y The observed sample

Returns:

0 if no problem

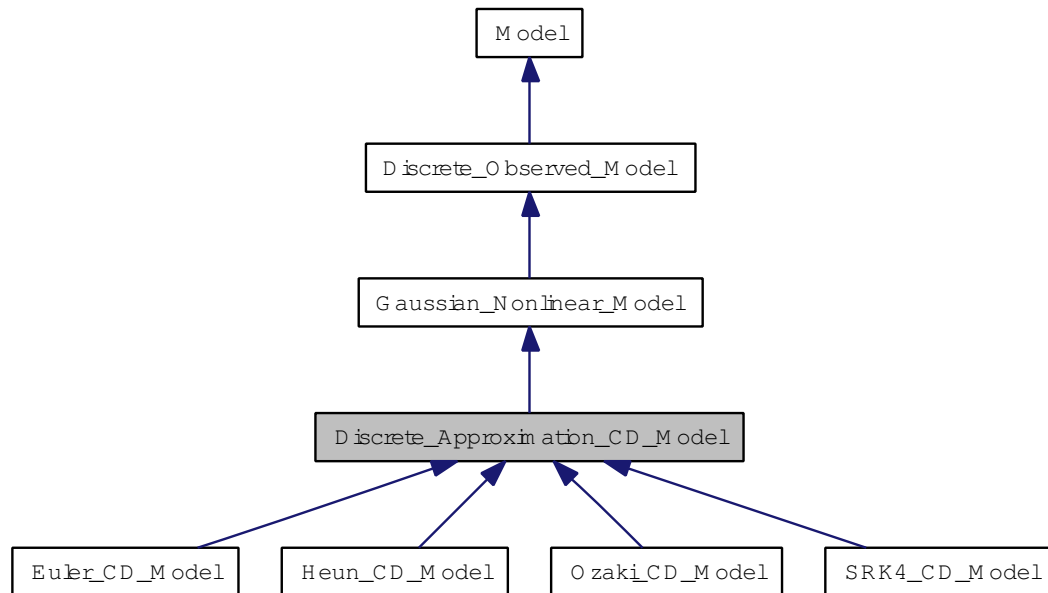
Implements [Filter](#).

8.11 Discrete_Approximation_CD_Model Class Reference

the continuous state equation is discretely approximate by $X(tk) = f^*(X(tk-1), Wk)$

```
#include <gaussian_model.h>
```

Inheritance diagram for Discrete_Approximation_CD_Model:



Public Member Functions

- [Discrete_Approximation_CD_Model](#) (void)
- virtual [~Discrete_Approximation_CD_Model](#) (void)
- [Discrete_Approximation_CD_Model](#) ([Continuous_Discrete_Model](#) *m)
- [Discrete_Approximation_CD_Model](#) ([Continuous_Discrete_Model](#) *m, const int &a)
the constructor
- [dcovector](#) [State_Function](#) (const [dcovector](#) &X, const [dcovector](#) &W)
The state $X_k = F(X_{k-1}, W_k)$.
- [dgematrix](#) [Jx_State_Function](#) (const [dcovector](#) &X, const [dcovector](#) &W)
the X jacobian of the State function evaluate at X, W
- void [Get_Linear_Parameters](#) (const [dcovector](#) &X, const [dcovector](#) &W, [dgematrix](#) &F, [dgematrix](#) &G, [dcovector](#) &Xp)
computed linearized parameter for EKF in X, W
- virtual void [Get_Linear_Scheme](#) (const [dcovector](#) &X, const [dcovector](#) &W, [dgematrix](#) &F, [dgematrix](#) &J, [dcovector](#) &Xp)=0
Get the Linearized parameters Scheme in X, W.
- [dgematrix](#) [Jw_State_Function](#) (const [dcovector](#) &X, const [dcovector](#) &W)

the W jacobian of the State function evaluate at X,W

- dcovector [Observation_Function](#) (const dcovector &X)

The observation $Y_k = H(X_k) + V_k$.

- virtual dgematrix [J_Observation_Function](#) (const dcovector &X)

the jacobian of the observation function evaluate at X

- virtual dcovector [Scheme](#) (const dcovector &X, const dcovector &W)=0
- virtual dgematrix [Jx_Scheme](#) (const dcovector &X, const dcovector &W)=0
- virtual dgematrix [Jw_Scheme](#) (const dcovector &X, const dcovector &W)=0
- virtual void [Init](#) (void)

Init The model if needed.

- void [Set_Alpha](#) (const int &a)
- int [Get_Alpha](#) (void)

Protected Attributes

- [Continuous_Discrete_Model](#) * [cd_model](#)

the continuous discrete model

- int [alpha](#)

*the resolution of the discrete step $T_d = T_s * a$ (T_s = sample duration of discrete observation)*

8.11.1 Detailed Description

the continuous state equation is discretly approximate by $X(tk) = f'(X(tk-1), W_k)$

8.11.2 Constructor & Destructor Documentation

8.11.2.1 [Discrete_Approximation_CD_Model::Discrete_Approximation_CD_Model](#) (void)

8.11.2.2 [virtual Discrete_Approximation_CD_Model::~Discrete_Approximation_CD_Model](#) (void) [virtual]

8.11.2.3 [Discrete_Approximation_CD_Model::Discrete_Approximation_CD_Model](#) (Continuous_Discrete_Model * *m*)

8.11.2.4 [Discrete_Approximation_CD_Model::Discrete_Approximation_CD_Model](#) (Continuous_Discrete_Model * *m*, const int &*a*)

the constructor

Parameters:

m the CD model

a the resolution of the discrete step $T_d = T_s * a$ (T_s = sample duration of discrete observation)

8.11.3 Member Function Documentation

8.11.3.1 `int Discrete_Approximation_CD_Model::Get_Alpha (void)`

8.11.3.2 `void Discrete_Approximation_CD_Model::Get_Linear_Parameters (const dcovector & X, const dcovector & W, dgematrix & F, dgematrix & G, dcovector & Xp) [virtual]`

computed linearized parameter for EKF in X,W

Parameters:

X The state value

W The noise value

F The jacobian of f(X,W) in X

G The jacobian in f(X,W) in W

Xp The prediction $X_p = f(X,W)$

Reimplemented from [Gaussian_Nonlinear_Model](#).

8.11.3.3 `virtual void Discrete_Approximation_CD_Model::Get_Linear_Scheme (const dcovector & X, const dcovector & W, dgematrix & F, dgematrix & J, dcovector & Xp) [pure virtual]`

Get the Linearized parameters Scheme in X,W.

Parameters:

X The state value

W The noise value

F The jacobian of f(X,W) in X

G The jacobian in f(X,W) in W

Xp The prediction $X_p = f(X,W)$

Implemented in [Euler_CD_Model](#), [SRK4_CD_Model](#), [Heun_CD_Model](#), and [Ozaki_CD_Model](#).

8.11.3.4 `virtual void Discrete_Approximation_CD_Model::Init (void) [virtual]`

Init The model if needed.

Reimplemented from [Gaussian_Nonlinear_Model](#).

8.11.3.5 `virtual dgematrix Discrete_Approximation_CD_Model::J_Observation_Function (const dcovector & X) [virtual]`

the jacobian of the observation function evaluate at X

Parameters:

X

Returns:

The jacobian matrix

Reimplemented from [Discrete_Observed_Model](#).

8.11.3.6 **virtual dgematrix Discrete_Approximation_CD_Model::Jw_Scheme (const dcovector & X, const dcovector & W) [pure virtual]**

Implemented in [Euler_CD_Model](#), [SRK4_CD_Model](#), [Heun_CD_Model](#), and [Ozaki_CD_Model](#).

8.11.3.7 **dgematrix Discrete_Approximation_CD_Model::Jw_State_Function (const dcovector & X, const dcovector & W) [virtual]**

the W jacobian of the State function evaluate at X,W

Parameters:

X evaluate at X

W evalate at W

Returns:

The jacobian matrix

Reimplemented from [Gaussian_Nonlinear_Model](#).

8.11.3.8 **virtual dgematrix Discrete_Approximation_CD_Model::Jx_Scheme (const dcovector & X, const dcovector & W) [pure virtual]**

Implemented in [Euler_CD_Model](#), [SRK4_CD_Model](#), [Heun_CD_Model](#), and [Ozaki_CD_Model](#).

8.11.3.9 **dgematrix Discrete_Approximation_CD_Model::Jx_State_Function (const dcovector & X, const dcovector & W) [virtual]**

the X jacobian of the State function evaluate at X,W

Parameters:

X evaluate at X

W evalate at W

Returns:

The jacobian matrix

Reimplemented from [Gaussian_Nonlinear_Model](#).

8.11.3.10 `dcovector Discrete_Approximation_CD_Model::Observation_Function (const dcovector & X)` [virtual]

The observation $Y_k = H(X_k) + V_k$.

Parameters:

X The state at k

Returns:

The observation at k

Implements [Discrete_Observed_Model](#).

8.11.3.11 `virtual dcovector Discrete_Approximation_CD_Model::Scheme (const dcovector & X, const dcovector & W)` [pure virtual]

Implemented in [Euler_CD_Model](#), [SRK4_CD_Model](#), [Heun_CD_Model](#), and [Ozaki_CD_Model](#).

8.11.3.12 `void Discrete_Approximation_CD_Model::Set_Alpha (const int & a)`

8.11.3.13 `dcovector Discrete_Approximation_CD_Model::State_Function (const dcovector & X, const dcovector & W)` [virtual]

The state $X_k = F(X_{k-1}, W_k)$.

Parameters:

X The state at $k-1$

W The Noise

Returns:

The state at k

Implements [Gaussian_Nonlinear_Model](#).

8.11.4 Member Data Documentation

8.11.4.1 `int Discrete_Approximation_CD_Model::alpha` [protected]

the resolution of the discrete step $T_d = T_s * a$ (T_s = sample duration of discrete observation)

8.11.4.2 `Continuous_Discrete_Model* Discrete_Approximation_CD_Model::cd_model` [protected]

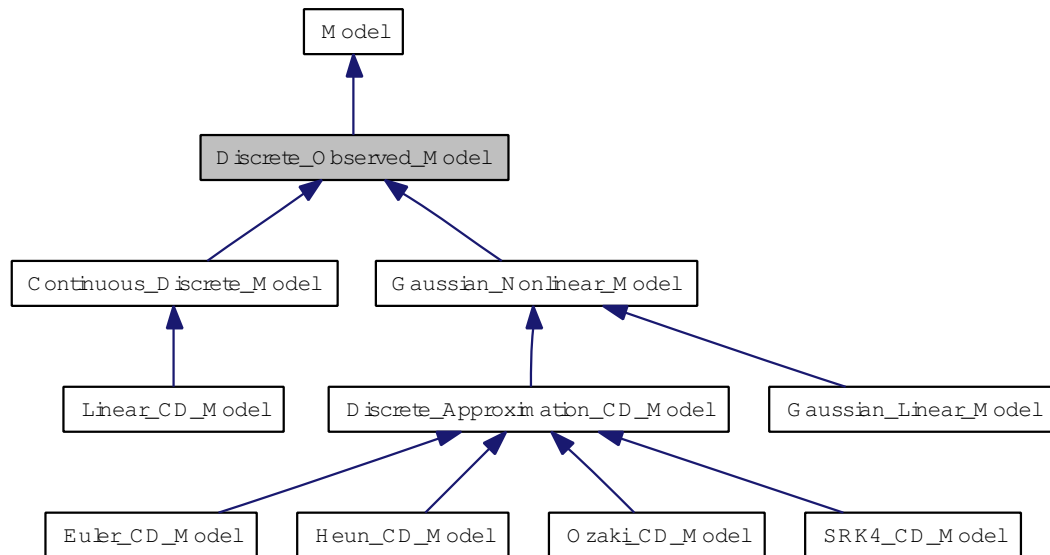
the continuous discrete model

8.12 Discrete_Observed_Model Class Reference

Class of discretely observed model.

```
#include <gaussian_model.h>
```

Inheritance diagram for Discrete_Observed_Model:



Public Member Functions

- [Discrete_Observed_Model](#) (void)
The Constructor.
- virtual [~Discrete_Observed_Model](#) (void)
The Destructor.
- virtual dcovector [Observation_Function](#) (const dcovector &X)=0
The observation $Y_k=H(X_k) + V_k$.
- virtual dgematrix [J_Observation_Function](#) (const dcovector &X)
the jacobian of the observation function evaluate at X
- virtual void [Get_Init_Parameters](#) (dcovector &mean, dsymatrix &Cov)
Return the first an second moment of the initial law $p(X_0)$.

Public Attributes

- dsymatrix [Qw](#)
The covariance matrix of state noise.
- dsymatrix [Qv](#)

The covariance matrix of observation noise.

Protected Attributes

- dsymatrix [R0](#)

The covariance matrix of $p(X0)$.

- dcovector [X0](#)

The mean of $p(X0)$.

8.12.1 Detailed Description

Class of discretely observed model.

The output Y_k is a discrete form of the hidden state. The init state is gaussian $\sim \mathcal{N}(X0, R0)$. The state and observation noises W_k, V_k are zero-mean gaussians processes. Their respective covariances are Q_w and Q_v .

8.12.2 Constructor & Destructor Documentation

8.12.2.1 Discrete_Observed_Model::Discrete_Observed_Model (void)

The Constructor.

8.12.2.2 virtual Discrete_Observed_Model::~~Discrete_Observed_Model (void) [virtual]

The Destructor.

Returns:

8.12.3 Member Function Documentation

8.12.3.1 virtual void Discrete_Observed_Model::Get_Init_Parameters (dcovector & *mean*, dsymatrix & *Cov*) [virtual]

Return the first and second moment of the initial law $p(X0)$.

Parameters:

mean The mean $X0$

Cov The Covariance $R0$

8.12.3.2 `virtual dgematrix Discrete_Observed_Model::J_Observation_Function (const dcovector & X) [virtual]`

the jacobian of the observation function evaluate at X

Parameters:

X

Returns:

The jacobian matrix

Reimplemented in [Gaussian_Linear_Model](#), [Linear_CD_Model](#), and [Discrete_Approximation_CD_Model](#).

8.12.3.3 `virtual dcovector Discrete_Observed_Model::Observation_Function (const dcovector & X) [pure virtual]`

The observation $Y_k = H(X_k) + V_k$.

Parameters:

X The state at k

Returns:

The observation at k

Implemented in [Gaussian_Linear_Model](#), [Linear_CD_Model](#), and [Discrete_Approximation_CD_Model](#).

8.12.4 Member Data Documentation

8.12.4.1 `dsymatrix Discrete_Observed_Model::Qv`

The covariance matrix of observation noise.

8.12.4.2 `dsymatrix Discrete_Observed_Model::Qw`

The covariance matrix of state noise.

8.12.4.3 `dsymatrix Discrete_Observed_Model::R0 [protected]`

The covariance matrix of $p(X_0)$.

8.12.4.4 `dcovector Discrete_Observed_Model::X0 [protected]`

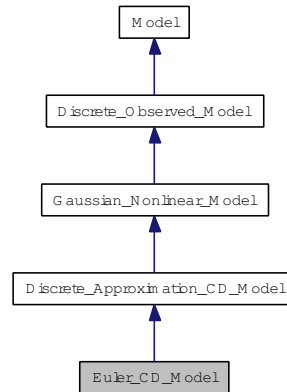
The mean of $p(X_0)$.

8.13 Euler_CD_Model Class Reference

continuous discret model: the state SDE is discretly approximate by an Euler method

```
#include <gaussian_model.h>
```

Inheritance diagram for Euler_CD_Model:



Public Member Functions

- [Euler_CD_Model](#) (void)
- [Euler_CD_Model](#) ([Continuous_Discrete_Model](#) *m, const int &a)
- dcovector [Scheme](#) (const dcovector &X, const dcovector &W)
- void [Get_Linear_Scheme](#) (const dcovector &X, const dcovector &W, dgematrix &F, dgematrix &J, dcovector &Xp)

Get the Linearized parameters Scheme in X,W.

- dgematrix [Jx_Scheme](#) (const dcovector &X, const dcovector &W)
- dgematrix [Jw_Scheme](#) (const dcovector &X, const dcovector &W)

8.13.1 Detailed Description

continuous discret model: the state SDE is discretly approximate by an Euler method

8.13.2 Constructor & Destructor Documentation

8.13.2.1 [Euler_CD_Model::Euler_CD_Model](#) (void)

8.13.2.2 [Euler_CD_Model::Euler_CD_Model](#) ([Continuous_Discrete_Model](#) * m, const int &a)

8.13.3 Member Function Documentation

8.13.3.1 void [Euler_CD_Model::Get_Linear_Scheme](#) (const dcovector & X, const dcovector & W, dgematrix & F, dgematrix & J, dcovector & Xp) [virtual]

Get the Linearized parameters Scheme in X,W.

Parameters:

- X The state value
- W The noise value
- F The jacobian of $f(X,W)$ in X
- G The jacobian in $f(X,W)$ in W
- Xp The prediction $Xp = f(X,W)$

Implements [Discrete_Approximation_CD_Model](#).

8.13.3.2 `dgematrix Euler_CD_Model::Jw_Scheme (const dcovector & X, const dcovector & W)`
[virtual]

Implements [Discrete_Approximation_CD_Model](#).

8.13.3.3 `dgematrix Euler_CD_Model::Jx_Scheme (const dcovector & X, const dcovector & W)`
[virtual]

Implements [Discrete_Approximation_CD_Model](#).

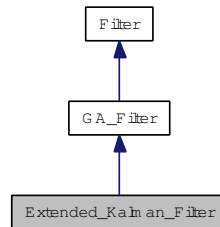
8.13.3.4 `dcovector Euler_CD_Model::Scheme (const dcovector & X, const dcovector & W)`
[virtual]

Implements [Discrete_Approximation_CD_Model](#).

8.14 Extended_Kalman_Filter Class Reference

```
#include <extended_kalman_filter.h>
```

Inheritance diagram for Extended_Kalman_Filter:



Public Member Functions

- [Extended_Kalman_Filter](#) (void)
- [Extended_Kalman_Filter](#) ([Gaussian_Nonlinear_Model](#) *m)

Protected Member Functions

- [int _update](#) (const [dcovector](#) &Y)

8.14.1 Constructor & Destructor Documentation

8.14.1.1 [Extended_Kalman_Filter::Extended_Kalman_Filter](#) (void)

8.14.1.2 [Extended_Kalman_Filter::Extended_Kalman_Filter](#) ([Gaussian_Nonlinear_Model](#) * m)

8.14.2 Member Function Documentation

8.14.2.1 [int Extended_Kalman_Filter::_update](#) (const [dcovector](#) & Y) [[protected](#), [virtual](#)]

Specific update for each filter

Parameters:

Y The observed sample

Returns:

0 if no problem

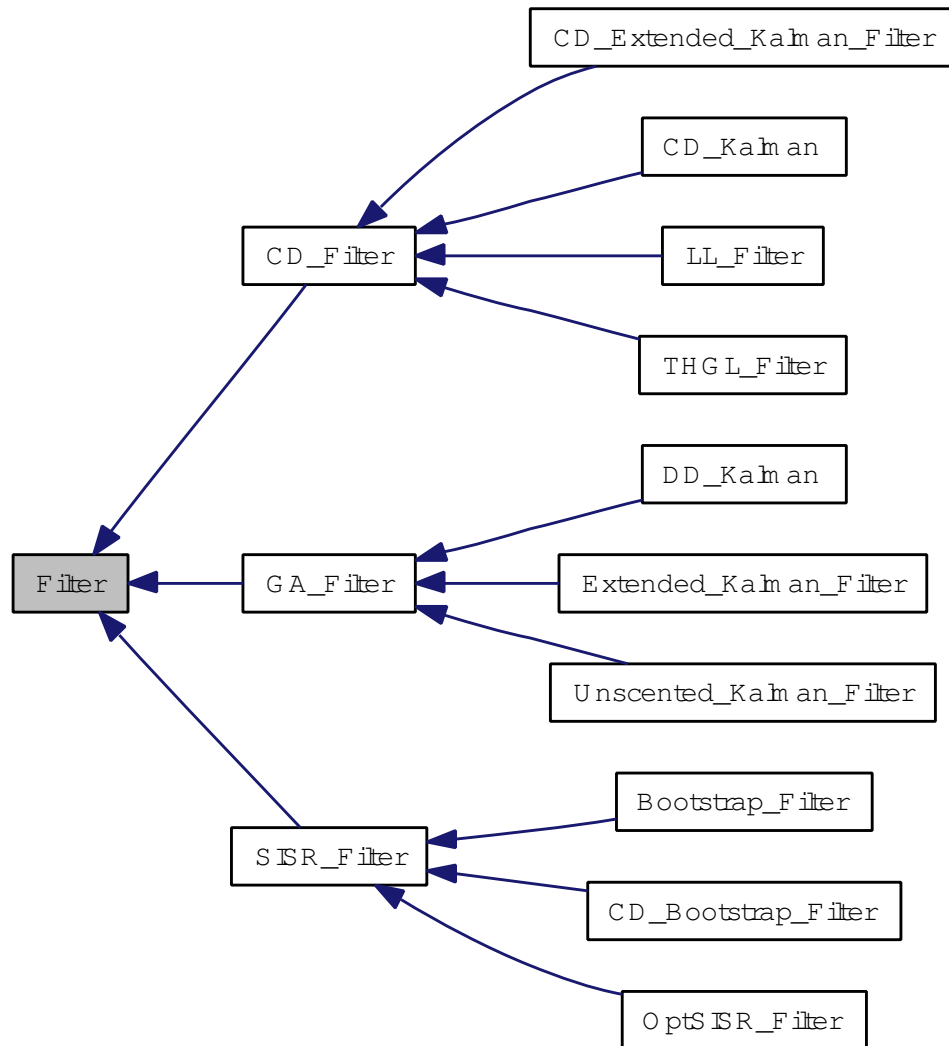
Implements [Filter](#).

8.15 Filter Class Reference

Abstract class of all filters.

```
#include <filter.h>
```

Inheritance diagram for Filter:



Public Member Functions

- `Filter` (void)
- virtual `~Filter` (void)
- int `Update` (const `dcovector` &Y)
- int `Filtering` (const `vector< dcovector >` &Y)
- virtual `dcovector Expected_Get` (void)=0
- int `Init` (void)
- double `Likelihood_Get` (void)
- virtual int `Save_X` (const char *filename)

Public Attributes

- [Model](#) * `model`
The hidden markov model.
- `vector< dcovector >` [X](#)
 $\{\hat{X}_{k|k}, k = 0, \dots, N\}$

Protected Member Functions

- `virtual int` [_update](#) (const dcovector &Y)=0
- `virtual int` [_init](#) (void)=0

Protected Attributes

- `double` [Likelihood](#)
The likelihood $p_{Y_{0:N}}(y_{0:N})$.

8.15.1 Detailed Description

Abstract class of all filters.

Filters calculate recursively an estimation $\hat{X}_{k|k}$ of the STATE X_k of a hidden markov model ([Model](#)) given observations $Y_{0:k}$.

They compute also recursively the likelihood $p_{Y_{0:N}}(y_{0:N})$.

8.15.2 Constructor & Destructor Documentation

8.15.2.1 `Filter::Filter (void)`

A constructor

8.15.2.2 `virtual Filter::~~Filter (void)` [`virtual`]

The destructor

8.15.3 Member Function Documentation

8.15.3.1 `virtual int Filter::_init (void)` [`protected`, `pure virtual`]

Specific init for each filter

Parameters:

Y The observed sample

Returns:

0 if no problem

Implemented in [GA_Filter](#), [CD_Filter](#), [SISR_Filter](#), and [Unscented_Kalman_Filter](#).

8.15.3.2 virtual int Filter::_update (const dcovector & Y) [protected, pure virtual]

Specific update for each filter

Parameters:

Y The observed sample

Returns:

0 if no problem

Implemented in [Extended_Kalman_Filter](#), [CD_Extended_Kalman_Filter](#), [CD_Kalman](#), [DD_Kalman](#), [LL_Filter](#), [SISR_Filter](#), [THGL_Filter](#), and [Unscented_Kalman_Filter](#).

8.15.3.3 virtual dcovector Filter::Expected_Get (void) [pure virtual]

Evaluate the current estimation of the state

Returns:

$\hat{X}_{k|k}$

Implemented in [GA_Filter](#), [CD_Filter](#), and [SISR_Filter](#).

8.15.3.4 int Filter::Filtering (const vector< dcovector > & Y)

Perform a trajectory state estimation given a sequence $y_{0:N}$

Parameters:

Y The sequence

Returns:

0 if everything is ok

8.15.3.5 int Filter::Init (void)

To init the filter at $k=0$

8.15.3.6 double Filter::Likelihood_Get (void)

Return the current likelihood $p_{Y_{0:k}}(y_{0:k})$

Returns:

$$p_{Y_{0:N}}(y_{0:N})$$

8.15.3.7 virtual int Filter::Save_X (const char *filename) [virtual]

Save the estimation $\{\hat{X}_{k|k}, k = 0, \dots, N\}$

Parameters:

filename

Returns:

0 if everything is ok

Reimplemented in [CD_Filter](#), and [CD_Bootstrap_Filter](#).

8.15.3.8 int Filter::Update (const dcovector & Y)

Perform an estimation step with a new observation

Parameters:

Y The new observed sample

Returns:

0 if everything is ok

8.15.4 Member Data Documentation**8.15.4.1 double Filter::Likelihood [protected]**

The likelihood $p_{Y_{0:N}}(y_{0:N})$.

8.15.4.2 Model* Filter::model

The hidden markov model.

8.15.4.3 vector<dcovector> Filter::X

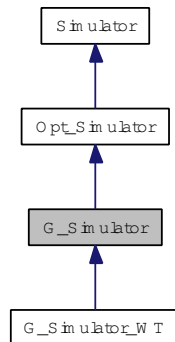
$$\{\hat{X}_{k|k}, k = 0, \dots, N\}$$

The estimated trajectory of the state

8.16 G_Simulator Class Reference

```
#include <simulator.h>
```

Inheritance diagram for G_Simulator:



Public Member Functions

- [G_Simulator](#) (void)
- [G_Simulator](#) ([Gaussian_Nonlinear_Model](#) *m)
- dcovector [Draw_Init](#) (void)
Draw a sample from $p(X_0)$.
- dcovector [Draw_Transition](#) (const dcovector &Xkm1)
Draw a sample from the transition density $p(X_k|X_{k-1})$.
- dcovector [Draw_Observation](#) (const dcovector &Xk)
Calculate the value of the density of probability of Y given X : $p(Y|X)$.
- long double [Observation_Density](#) (const dcovector &Y, const dcovector &X)
calculate the value of the density of probability of Y given X : $p(Y|X)$
- dcovector [Draw_Optimal](#) (const dcovector &Yk, const dcovector &Xkm1)
Draw a sample from the optimal density $p(X_k|Y_k, X_{k-1})$.
- long double [Obs_Optimal_Density](#) (const dcovector &Yk, const dcovector &Xkm1)
calculate the value of the density of probability of Yk given Xk-1 : $p(Y_k|X_{k-1})$

8.16.1 Constructor & Destructor Documentation

8.16.1.1 `G_Simulator::G_Simulator (void)`

8.16.1.2 `G_Simulator::G_Simulator (Gaussian_Nonlinear_Model * m)`

8.16.2 Member Function Documentation

8.16.2.1 `dcovector G_Simulator::Draw_Init (void)` `[virtual]`

Draw a sample from $p(X_0)$.

Returns:

A sample from $p(X_0)$

Implements [Simulator](#).

Reimplemented in [G_Simulator_WT](#).

8.16.2.2 `dcovector G_Simulator::Draw_Observation (const dcovector & Xk)` `[virtual]`

Calculate the value of the density of probability of Y given X : $p(Y|X)$.

Parameters:

Xk The state at k

Returns:

The simulated observation

Implements [Simulator](#).

8.16.2.3 `dcovector G_Simulator::Draw_Optimal (const dcovector & Yk, const dcovector & Xkm1)`
`[virtual]`

Draw a sample from the optimal density $p(X_k|Y_k, X_{k-1})$.

Parameters:

Yk The observation at k

Xkm1 $X(k-1)$ the state value at $k-1$

Returns:

A sample from the optimal importance density

Implements [Opt_Simulator](#).

8.16.2.4 dcovector G_Simulator::Draw_Transition (const dcovector & *Xkm1*) [virtual]

Draw a sample from the transition density $p(X_k|X_{k-1})$.

Parameters:

Xkm1 $X_{(k-1)}$ the preceding state

Returns:

Implements [Simulator](#).

8.16.2.5 long double G_Simulator::Obs_Optimal_Density (const dcovector & *Yk*, const dcovector & *Xkm1*) [virtual]

calculate the value of the density of probability of Y_k given X_{k-1} : $p(Y_k|X_{k-1})$

Parameters:

Yk the osbervation at k

Xkm1 The state at k-1

Returns:

The value of the density $p(Y_k|X_{k-1})$

Implements [Opt_Simulator](#).

8.16.2.6 long double G_Simulator::Observation_Density (const dcovector & *Y*, const dcovector & *X*) [virtual]

calculate the value of the density of probability of Y given X : $p(Y|X)$

Parameters:

Y The osbervation

X The state

Returns:

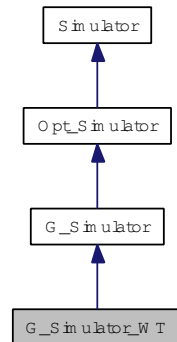
The value of the density

Implements [Simulator](#).

8.17 G_Simulator_WT Class Reference

```
#include <simulator.h>
```

Inheritance diagram for G_Simulator_WT:



Public Member Functions

- [G_Simulator_WT](#) (void)
- [G_Simulator_WT](#) ([Gaussian_Nonlinear_Model](#) *m, const int &NB, const int &N)
- dcovector [Draw_Init](#) (void)

Draw a sample from $p(X_0)$.

Private Attributes

- vector< dcovector > [Xt](#)
- int [NB](#)
- int [N](#)

8.17.1 Constructor & Destructor Documentation

8.17.1.1 [G_Simulator_WT::G_Simulator_WT](#) (void)

8.17.1.2 [G_Simulator_WT::G_Simulator_WT](#) ([Gaussian_Nonlinear_Model](#) *m, const int &NB, const int &N)

8.17.2 Member Function Documentation

8.17.2.1 dcovector [G_Simulator_WT::Draw_Init](#) (void) [virtual]

Draw a sample from $p(X_0)$.

Returns:

A sample from $p(X_0)$

Reimplemented from [G_Simulator](#).

8.17.3 Member Data Documentation

8.17.3.1 `int G_Simulator_WT::N` `[private]`

8.17.3.2 `int G_Simulator_WT::NB` `[private]`

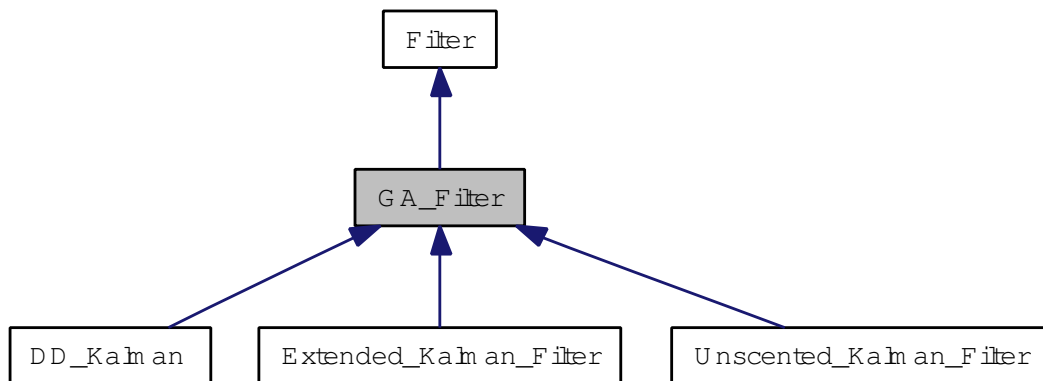
8.17.3.3 `vector<dcovector> G_Simulator_WT::Xt` `[private]`

8.18 GA_Filter Class Reference

Abstract class of Gaussian Approximation filters.

```
#include <filter.h>
```

Inheritance diagram for GA_Filter:



Public Member Functions

- [GA_Filter](#) (void)
A constructor.
- [GA_Filter](#) ([Gaussian_Nonlinear_Model](#) *m)
- dcovector [Expected_Get](#) (void)

Public Attributes

- dcovector [M](#)
The current mean $\hat{X}_{k|k} = E[X_k|Y_{0:k}]$.
- dgematrix [R](#)
The current covariance $\hat{P}_{k|k} = E[(X_k - \hat{X}_{k|k})(X_k - \hat{X}_{k|k})]$.
- dcovector [Xp](#)
The prediction $\hat{X}_{k-1|k} = E[X_{k-1}|Y_{0:k}]$.
- dgematrix [Rp](#)
The prediction covariance $\hat{P}_{k-1|k} = E[(X_k - \hat{X}_{k-1|k})(X_k - \hat{X}_{k-1|k})]$.

Protected Member Functions

- virtual int [_init](#) (void)

8.18.1 Detailed Description

Abstract class of Gaussian Approximation filters.

For discrete-discrete models ([Gaussian_Nonlinear_Model](#)), these filters approximate the probability density of the state transition $p_{X_k|X_{k-1}}$ and the probability of the observation $p_{Y_k|X_k}$ by gaussian densities. The approximation is exact in the case of linear model ([Gaussian_Linear_Model](#)) and lead to the discrete-discrete Kalman [Filter](#) ([DD_Kalman](#)). For other non-linear models ([Gaussian_Nonlinear_Model](#)) UKF ([Unscented_Kalman_Filter](#)) or EKF ([Extended_Kalman_Filter](#)) can be used.

8.18.2 Constructor & Destructor Documentation

8.18.2.1 `GA_Filter::GA_Filter (void)`

A constructor.

8.18.2.2 `GA_Filter::GA_Filter (Gaussian_Nonlinear_Model * m)`

A constructor

Parameters:

m A discrete-discrete gaussian non-linear model

8.18.3 Member Function Documentation

8.18.3.1 `virtual int GA_Filter::_init (void)` [protected, virtual]

Specific init for each filter

Parameters:

Y The observed sample

Returns:

0 if no problem

Implements [Filter](#).

Reimplemented in [Unscented_Kalman_Filter](#).

8.18.3.2 `dcovector GA_Filter::Expected_Get (void)` [virtual]

Get the current estimation $\hat{X}_{k|k}$

Returns:

$\hat{X}_{k|k}$

Implements [Filter](#).

8.18.4 Member Data Documentation

8.18.4.1 dcovector GA_Filter::M

The current mean $\hat{X}_{k|k} = E[X_k | Y_{0:k}]$.

8.18.4.2 dgematrix GA_Filter::R

The current covariance $\hat{P}_{k|k} = E[(X_k - \hat{X}_{k|k})(X_k - \hat{X}_{k|k})]$.

8.18.4.3 dgematrix GA_Filter::Rp

The prediction covariance $\hat{P}_{k-1|k} = E[(X_k - \hat{X}_{k-1|k})(X_k - \hat{X}_{k-1|k})]$.

8.18.4.4 dcovector GA_Filter::Xp

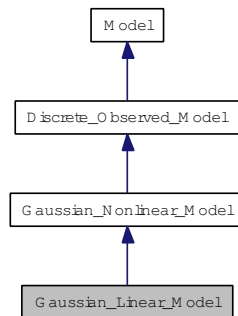
The prediction $\hat{X}_{k-1|k} = E[X_{k-1} | Y_{0:k}]$.

8.19 Gaussian_Linear_Model Class Reference

Gaussian Linear [Model](#) .:

```
#include <gaussian_model.h>
```

Inheritance diagram for Gaussian_Linear_Model:



Public Member Functions

- [Gaussian_Linear_Model](#) (void)
- dcovector [State_Function](#) (const dcovector &X, const dcovector &W)
The state $X_k = F(X_{k-1}, W_k)$.
- dgematrix [Jx_State_Function](#) (const dcovector &X, const dcovector &W)
the X jacobian of the State function evaluate at X, W
- dgematrix [Jw_State_Function](#) (const dcovector &X, const dcovector &W)
the W jacobian of the State function evaluate at X, W
- dcovector [Get_Mean_Prediction](#) (const dcovector &M)
- dgematrix [Get_Cov_Prediction](#) (const dgematrix &P)
- dcovector [Observation_Function](#) (const dcovector &X)
The observation $Y_k = H(X_k) + V_k$.
- dgematrix [J_Observation_Function](#) (const dcovector &X)
the jacobian of the observation function evaluate at X

Public Attributes

- dgematrix [F](#)
- dgematrix [G](#)
- dcovector [f](#)
- dcovector [h](#)
- dgematrix [H](#)

8.19.1 Detailed Description

Gaussian Linear [Model](#) .

The state : $X(k) = F X(k-1) + f + G * W_k$ The Observation $Y(k) = H X(k) + h + V$

8.19.2 Constructor & Destructor Documentation

8.19.2.1 `Gaussian_Linear_Model::Gaussian_Linear_Model (void)`

8.19.3 Member Function Documentation

8.19.3.1 `dgematrix Gaussian_Linear_Model::Get_Cov_Prediction (const dgematrix & P)`

8.19.3.2 `dcovector Gaussian_Linear_Model::Get_Mean_Prediction (const dcovector & M)`

8.19.3.3 `dgematrix Gaussian_Linear_Model::J_Observation_Function (const dcovector & X)`
[virtual]

the jacobian of the observation function evaluate at X

Parameters:

X

Returns:

The jacobian matrix

Reimplemented from [Discrete_Observed_Model](#).

8.19.3.4 `dgematrix Gaussian_Linear_Model::Jw_State_Function (const dcovector & X, const dcovector & W)` [virtual]

the W jacobian of the State function evaluate at X,W

Parameters:

X evaluate at X

W evalate at W

Returns:

The jacobian matrix

Reimplemented from [Gaussian_Nonlinear_Model](#).

8.19.3.5 `dgematrix Gaussian_Linear_Model::Jx_State_Function (const dcovector & X, const dcovector & W)` [virtual]

the X jacobian of the State function evaluate at X,W

Parameters: X evaluate at X W evalate at W **Returns:**

The jacobian matrix

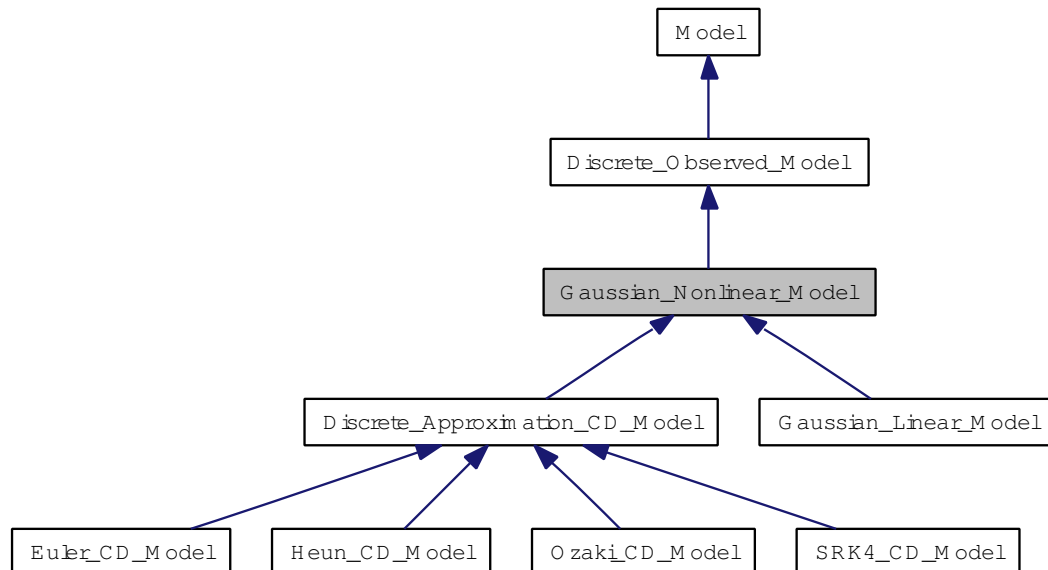
Reimplemented from [Gaussian_Nonlinear_Model](#).**8.19.3.6 dcovector Gaussian_Linear_Model::Observation_Function (const dcovector & X)**
[virtual]The observation $Y_k = H(X_k) + V_k$.**Parameters:** X The state at k **Returns:**The observation at k Implements [Discrete_Observed_Model](#).**8.19.3.7 dcovector Gaussian_Linear_Model::State_Function (const dcovector & X , const dcovector & W)** [virtual]The state $X_k = F(X_{k-1}, W_k)$.**Parameters:** X The state at $k-1$ W The Noise**Returns:**The state at k Implements [Gaussian_Nonlinear_Model](#).**8.19.4 Member Data Documentation****8.19.4.1 dcovector Gaussian_Linear_Model::f****8.19.4.2 dgematrix Gaussian_Linear_Model::F****8.19.4.3 dgematrix Gaussian_Linear_Model::G****8.19.4.4 dgematrix Gaussian_Linear_Model::H****8.19.4.5 dcovector Gaussian_Linear_Model::h**

8.20 Gaussian_Nonlinear_Model Class Reference

Gaussian Nonlinear [Model](#) The state : $X(k) = F(X_{k-1}, W_k)$ The Observation $Y(k) = H(X(k)) + V$.

```
#include <gaussian_model.h>
```

Inheritance diagram for Gaussian_Nonlinear_Model:



Public Member Functions

- [Gaussian_Nonlinear_Model](#) (void)
- virtual [~Gaussian_Nonlinear_Model](#) (void)
- virtual void [Init](#) (void)
Init The model if needed.
- virtual dcovector [State_Function](#) (const dcovector &X, const dcovector &W)=0
The state $X_k = F(X_{k-1}, W_k)$.
- virtual dgematrix [Jx_State_Function](#) (const dcovector &X, const dcovector &W)
the X jacobian of the State function evaluate at X,W
- virtual dgematrix [Jw_State_Function](#) (const dcovector &X, const dcovector &W)
the W jacobian of the State function evaluate at X,W
- virtual void [Get_Linear_Parameters](#) (const dcovector &X, const dcovector &W, dgematrix &F, dgematrix &G, dcovector &Xp)
computed linearized parameter for EKF in X,W

8.20.1 Detailed Description

Gaussian Nonlinear [Model](#) The state : $X(k) = F(X_{k-1}, W_k)$ The Observation $Y(k) = H(X(k)) + V$.

8.20.2 Constructor & Destructor Documentation

8.20.2.1 `Gaussian_Nonlinear_Model::Gaussian_Nonlinear_Model (void)`

8.20.2.2 `virtual Gaussian_Nonlinear_Model::~~Gaussian_Nonlinear_Model (void)` [virtual]

8.20.3 Member Function Documentation

8.20.3.1 `virtual void Gaussian_Nonlinear_Model::Get_Linear_Parameters (const dcovector & X, const dcovector & W, dgematrix & F, dgematrix & G, dcovector & Xp)` [virtual]

computed linearized parameter for EKF in X,W

Parameters:

X The state value

W The noise value

F The jacobian of $f(X,W)$ in X

G The jacobian in $f(X,W)$ in W

Xp The prediction $Xp = f(X,W)$

Reimplemented in [Discrete_Approximation_CD_Model](#).

8.20.3.2 `virtual void Gaussian_Nonlinear_Model::Init (void)` [virtual]

Init The model if needed.

Reimplemented in [Discrete_Approximation_CD_Model](#).

8.20.3.3 `virtual dgematrix Gaussian_Nonlinear_Model::Jw_State_Function (const dcovector & X, const dcovector & W)` [virtual]

the W jacobian of the State function evaluate at X,W

Parameters:

X evaluate at X

W evalate at W

Returns:

The jacobian matrix

Reimplemented in [Gaussian_Linear_Model](#), and [Discrete_Approximation_CD_Model](#).

8.20.3.4 `virtual dgematrix Gaussian_Nonlinear_Model::Jx_State_Function (const dcovector & X, const dcovector & W)` [virtual]

the X jacobian of the State function evaluate at X,W

Parameters:

X evaluate at X

W evaluate at W

Returns:

The jacobian matrix

Reimplemented in [Gaussian_Linear_Model](#), and [Discrete_Approximation_CD_Model](#).

8.20.3.5 virtual dcovector Gaussian_Nonlinear_Model::State_Function (const dcovector & X , const dcovector & W) [pure virtual]

The state $X_k = F(X_{k-1}, W_k)$.

Parameters:

X The state at $k-1$

W The Noise

Returns:

The state at k

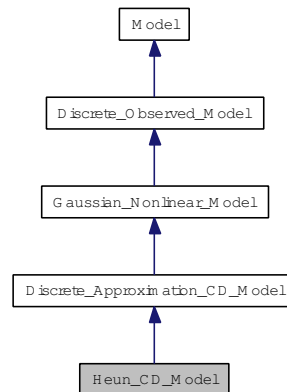
Implemented in [Gaussian_Linear_Model](#), and [Discrete_Approximation_CD_Model](#).

8.21 Heun_CD_Model Class Reference

continuous discret model: the state SDE is discretely approximate by an Sstochastic Heun method

```
#include <gaussian_model.h>
```

Inheritance diagram for Heun_CD_Model:



Public Member Functions

- [Heun_CD_Model](#) (void)
- [Heun_CD_Model](#) ([Continuous_Discrete_Model](#) *m, const int &a)
- dcovector [Scheme](#) (const dcovector &X, const dcovector &W)
- dgematrix [Jx_Scheme](#) (const dcovector &X, const dcovector &W)
- dgematrix [Jw_Scheme](#) (const dcovector &X, const dcovector &W)
- void [Get_Linear_Scheme](#) (const dcovector &X, const dcovector &W, dgematrix &F, dgematrix &J, dcovector &Xp)

Get the Linearized parameters Scheme in X,W.

8.21.1 Detailed Description

continuous discret model: the state SDE is discretely approximate by an Sstochastic Heun method

8.21.2 Constructor & Destructor Documentation

8.21.2.1 [Heun_CD_Model::Heun_CD_Model](#) (void)

8.21.2.2 [Heun_CD_Model::Heun_CD_Model](#) ([Continuous_Discrete_Model](#) * m, const int &a)

8.21.3 Member Function Documentation

8.21.3.1 void [Heun_CD_Model::Get_Linear_Scheme](#) (const dcovector & X, const dcovector & W, dgematrix & F, dgematrix & J, dcovector & Xp) [virtual]

Get the Linearized parameters Scheme in X,W.

Parameters:

- X The state value
- W The noise value
- F The jacobian of $f(X,W)$ in X
- G The jacobian in $f(X,W)$ in W
- Xp The prediction $Xp = f(X,W)$

Implements [Discrete_Approximation_CD_Model](#).

8.21.3.2 dgematrix Heun_CD_Model::Jw_Scheme (const dcovector & X, const dcovector & W)
[virtual]

Implements [Discrete_Approximation_CD_Model](#).

8.21.3.3 dgematrix Heun_CD_Model::Jx_Scheme (const dcovector & X, const dcovector & W)
[virtual]

Implements [Discrete_Approximation_CD_Model](#).

8.21.3.4 dcovector Heun_CD_Model::Scheme (const dcovector & X, const dcovector & W)
[virtual]

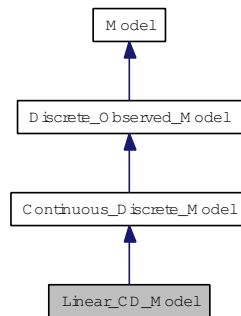
Implements [Discrete_Approximation_CD_Model](#).

8.22 Linear_CD_Model Class Reference

Linear continuous discrete model class of the form $dx = AX dt + Bdt + CdW$ $Y_k = HX(t_k) + h + V_k$.

```
#include <gaussian_model.h>
```

Inheritance diagram for Linear_CD_Model:



Public Member Functions

- [Linear_CD_Model](#) (void)
- dcovector [Drift_Function](#) (const dcovector &X)
*the drift function of $dX(t) = F(X)dt + G(X)*dW$*
- dgematrix [J_Drift_Function](#) (const dcovector &X)
the jacobian of the drift function evaluate at X
- dgematrix [Diffusion_Function](#) (void)
the diffusion function
- dcovector [Observation_Function](#) (const dcovector &X)
The observation $Y_k = H(X_k) + V_k$.
- dgematrix [J_Observation_Function](#) (const dcovector &X)
the jacobian of the observation function evaluate at X
- dcovector [Get_Mean_Prediction](#) (const dcovector &M)
- dgematrix [Get_Cov_Prediction](#) (const dgematrix &P)
- virtual void [Init](#) (void)

Public Attributes

- dgematrix [A](#)
- dcovector [B](#)
- dgematrix [C](#)
- dcovector [h](#)
- dgematrix [H](#)

8.22.1 Detailed Description

Linear continuous discrete model class of the form $dx = AX dt + Bdt + CdW$ $Y_k = HX(t_k) + h + V_k$.

8.22.2 Constructor & Destructor Documentation

8.22.2.1 Linear_CD_Model::Linear_CD_Model (void)

8.22.3 Member Function Documentation

8.22.3.1 dgematrix Linear_CD_Model::Diffusion_Function (void) [virtual]

the diffusion function

Parameters:

X the state

Returns:

$G(X)$.

Implements [Continuous_Discrete_Model](#).

8.22.3.2 dcovector Linear_CD_Model::Drift_Function (const dcovector & X) [virtual]

the drift function of $dX(t) = F(X)dt + G(X)*dW$

Parameters:

X the state.

Returns:

$f(X)$

Implements [Continuous_Discrete_Model](#).

8.22.3.3 dgematrix Linear_CD_Model::Get_Cov_Prediction (const dgematrix & P)

8.22.3.4 dcovector Linear_CD_Model::Get_Mean_Prediction (const dcovector & M)

8.22.3.5 virtual void Linear_CD_Model::Init (void) [inline, virtual]

Initialized CD model

Reimplemented from [Continuous_Discrete_Model](#).

8.22.3.6 dgematrix Linear_CD_Model::J_Drift_Function (const dcovector & X) [virtual]

the jacobian of the drift function evaluate at X

Parameters: X **Returns:**

the jacobian matrix

Reimplemented from [Continuous_Discrete_Model](#).**8.22.3.7 dgematrix Linear_CD_Model::J_Observation_Function (const dcovector & X)**
[virtual]the jacobian of the observation function evaluate at X **Parameters:** X **Returns:**

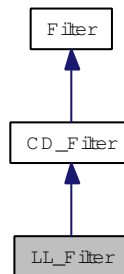
The jacobian matrix

Reimplemented from [Discrete_Observed_Model](#).**8.22.3.8 dcovector Linear_CD_Model::Observation_Function (const dcovector & X)**
[virtual]The observation $Y_k = H(X_k) + V_k$.**Parameters:** X The state at k **Returns:**The observation at k Implements [Discrete_Observed_Model](#).**8.22.4 Member Data Documentation****8.22.4.1 dgematrix Linear_CD_Model::A****8.22.4.2 dcovector Linear_CD_Model::B****8.22.4.3 dgematrix Linear_CD_Model::C****8.22.4.4 dgematrix Linear_CD_Model::H****8.22.4.5 dcovector Linear_CD_Model::h**

8.23 LL_Filter Class Reference

```
#include <local_linearization_filter.h>
```

Inheritance diagram for LL_Filter:



Public Member Functions

- [LL_Filter](#) (void)
- [LL_Filter](#) ([Continuous_Discrete_Model](#) *m)

Protected Member Functions

- [int _update](#) (const dcovector &Y)

8.23.1 Constructor & Destructor Documentation

8.23.1.1 [LL_Filter::LL_Filter](#) (void)

8.23.1.2 [LL_Filter::LL_Filter](#) ([Continuous_Discrete_Model](#) * *m*)

8.23.2 Member Function Documentation

8.23.2.1 [int LL_Filter::_update](#) (const dcovector & *Y*) [protected, virtual]

Specific update for each filter

Parameters:

Y The observed sample

Returns:

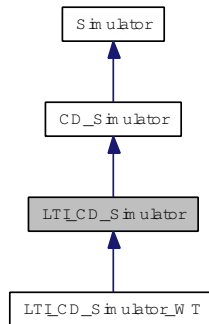
0 if no problem

Implements [Filter](#).

8.24 LTI_CD_Simulator Class Reference

```
#include <simulator.h>
```

Inheritance diagram for LTI_CD_Simulator:



Public Member Functions

- [LTI_CD_Simulator](#) (void)
- [LTI_CD_Simulator](#) ([Linear_CD_Model](#) *cd_m, const int &apha=1)

Protected Member Functions

- dcovector [draw_state](#) (const dcovector &X)

8.24.1 Constructor & Destructor Documentation

8.24.1.1 [LTI_CD_Simulator::LTI_CD_Simulator](#) (void)

8.24.1.2 [LTI_CD_Simulator::LTI_CD_Simulator](#) ([Linear_CD_Model](#) * *cd_m*, const int & *apha* = 1)

8.24.2 Member Function Documentation

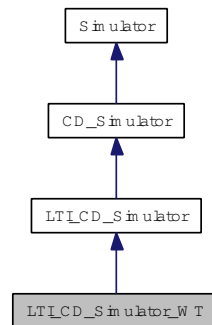
8.24.2.1 dcovector [LTI_CD_Simulator::draw_state](#) (const dcovector & *X*) [protected, virtual]

Reimplemented from [CD_Simulator](#).

8.25 LTI_CD_Simulator_WT Class Reference

```
#include <simulator.h>
```

Inheritance diagram for LTI_CD_Simulator_WT:



Public Member Functions

- [LTI_CD_Simulator_WT](#) (void)
- [LTI_CD_Simulator_WT](#) ([Linear_CD_Model](#) **cd_m*, const int &*apha*, const double &*tb*, const double &*t*)
- dcovector [Draw_Init](#) (void)
Draw a sample from $p(X_0)$.

Private Attributes

- vector< dcovector > [Xt](#)
- double [TB](#)
- double [T](#)

8.25.1 Constructor & Destructor Documentation

8.25.1.1 [LTI_CD_Simulator_WT::LTI_CD_Simulator_WT](#) (void)

8.25.1.2 [LTI_CD_Simulator_WT::LTI_CD_Simulator_WT](#) ([Linear_CD_Model](#) * *cd_m*, const int & *apha*, const double & *tb*, const double & *t*)

8.25.2 Member Function Documentation

8.25.2.1 dcovector [LTI_CD_Simulator_WT::Draw_Init](#) (void) [virtual]

Draw a sample from $p(X_0)$.

Returns:

A sample from $p(X_0)$

Reimplemented from [CD_Simulator](#).

8.25.3 Member Data Documentation

8.25.3.1 `double LTI_CD_Simulator_WT::T` [private]

8.25.3.2 `double LTI_CD_Simulator_WT::TB` [private]

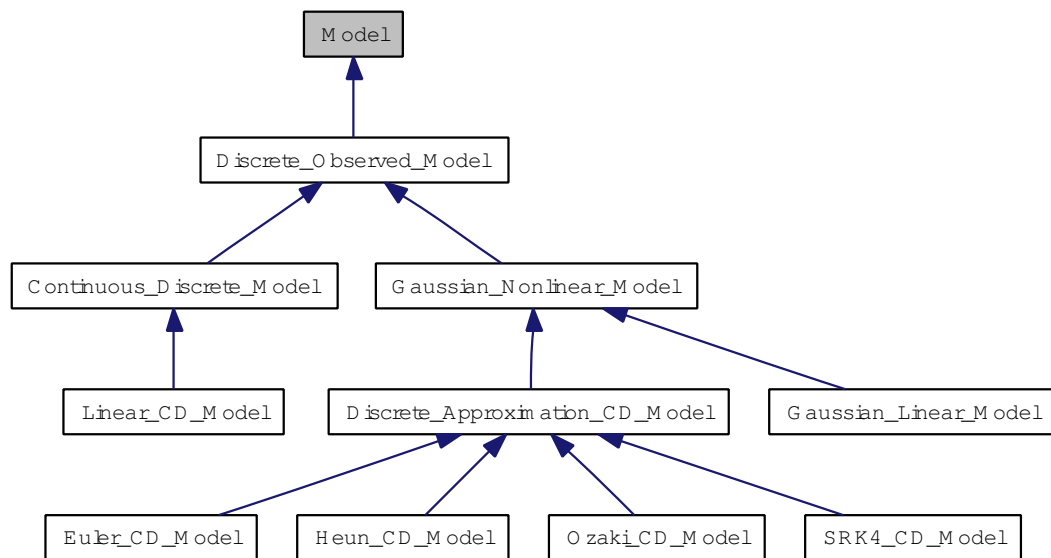
8.25.3.3 `vector<dcovector> LTI_CD_Simulator_WT::Xt` [private]

8.26 Model Class Reference

The class of time varying-models.

```
#include <gaussian_model.h>
```

Inheritance diagram for Model:



Public Member Functions

- **Model** (void)
- virtual **~Model** (void)
The Destructor.
- int **Update** (void)
Update the time.
- int **Clear** (void)
Set the time to 0.
- int **Get_Time** (void)
Get The current time.

Protected Attributes

- int **_k**
The time.

8.26.1 Detailed Description

The class of time varying-models.

8.26.2 Constructor & Destructor Documentation

8.26.2.1 `Model::Model (void)`

8.26.2.2 `virtual Model::~Model (void)` `[virtual]`

The Destructor.

Returns:

8.26.3 Member Function Documentation

8.26.3.1 `int Model::Clear (void)`

Set the time to 0.

Returns:

0 if it's Ok;

8.26.3.2 `int Model::Get_Time (void)`

Get The current time.

Returns:

8.26.3.3 `int Model::Update (void)`

Update the time.

Returns:

0 if it's Ok;

8.26.4 Member Data Documentation

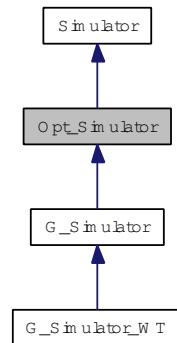
8.26.4.1 `int Model::_k` `[protected]`

The time.

8.27 Opt_Simulator Class Reference

```
#include <simulator.h>
```

Inheritance diagram for Opt_Simulator:



Public Member Functions

- [Opt_Simulator](#) (void)
- virtual dcovector [Draw_Optimal](#) (const dcovector &Yk, const dcovector &Xkm1)=0
Draw a sample from the optimal densisty $p(X_k|Y_k, X_{k-1})$.
- virtual long double [Obs_Optimal_Density](#) (const dcovector &Yk, const dcovector &Xkm1)=0
calculate the value of the density of probability of Y_k given X_{k-1} : $p(Y_k|X_{k-1})$

8.27.1 Constructor & Destructor Documentation

8.27.1.1 Opt_Simulator::Opt_Simulator (void)

8.27.2 Member Function Documentation

8.27.2.1 virtual dcovector Opt_Simulator::Draw_Optimal (const dcovector & Yk, const dcovector & Xkm1) [pure virtual]

Draw a sample from the optimal densisty $p(X_k|Y_k, X_{k-1})$.

Parameters:

Yk The obseration at k

Xkm1 X(k-1) the state value at k-1

Returns:

A sample from the optimal importance density

Implemented in [G_Simulator](#).

8.27.2.2 virtual long double Opt_Simulator::Obs_Optimal_Density (const dcovector & *Yk*, const dcovector & *Xkm1*) [pure virtual]

calculate the value of the density of probability of Y_k given X_{k-1} : $p(Y_k|X_{k-1})$

Parameters:

Yk the osbervation at k

Xkm1 The state at k-1

Returns:

The value of the density $p(Y_k|X_{k-1})$

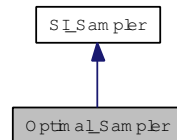
Implemented in [G_Simulator](#).

8.28 Optimal_Sampler Class Reference

This sampler use the optimal importance density.

```
#include <sisr_filter.h>
```

Inheritance diagram for Optimal_Sampler:



Public Member Functions

- [Optimal_Sampler](#) (void)
- [Optimal_Sampler](#) ([Opt_Simulator](#) *m)
- [vector< Weighted_Sample > DrawInitCloud](#) (const int &NbSample)
draw a set of possible init state
- [vector< Weighted_Sample > Draw](#) (const [dcovector](#) &Y_k, const [vector< Weighted_Sample >](#) &X_km1)
Draw a set of samples from the importance density Xk given Y0:k X0:k-1.
- long double [Weight](#) ([vector< Weighted_Sample >](#) &cloud, const [dcovector](#) &Y_k, const [vector< Weighted_Sample >](#) &X_km1)
Modify the weights of cloud for the weighting step in the sisr.

8.28.1 Detailed Description

This sampler use the optimal importance density.

8.28.2 Constructor & Destructor Documentation

8.28.2.1 [Optimal_Sampler::Optimal_Sampler](#) (void)

8.28.2.2 [Optimal_Sampler::Optimal_Sampler](#) ([Opt_Simulator](#) * m)

8.28.3 Member Function Documentation

8.28.3.1 [vector<Weighted_Sample > Optimal_Sampler::Draw](#) (const [dcovector](#) & Y_k, const [vector< Weighted_Sample >](#) & X_km1) [virtual]

Draw a set of samples from the importance density Xk given Y0:k X0:k-1.

Parameters:

Y_k The observation from 0 to k

X_km1 The cloud from 0 to km1

Returns:

A cloud representing the importance density $q(X_k|Y_{0:k}, X_{0:k-1})$

Implements [SI_Sampler](#).

8.28.3.2 `vector<Weighted_Sample> Optimal_Sampler::DrawInitCloud (const int & NbSample)`
[virtual]

draw a set of possible init state

Parameters:

NbSample Number of sample

Returns:

A set of weighted samples

Implements [SI_Sampler](#).

8.28.3.3 `long double Optimal_Sampler::Weight (vector< Weighted_Sample> & cloud, const dcovector & Y_k, const vector< Weighted_Sample> & X_km1)` [virtual]

Modify the weights of cloud for the weighting step in the sirs.

Parameters:

cloud The curent coud at k

Y_k The observation at k

X_km1 the cloud from at km1

Returns:

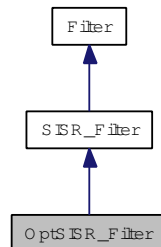
The sum of the weights

Implements [SI_Sampler](#).

8.29 OptSISR_Filter Class Reference

```
#include <sisr_filter.h>
```

Inheritance diagram for OptSISR_Filter:



Public Member Functions

- [OptSISR_Filter](#) (void)
- [~OptSISR_Filter](#) (void)
- [OptSISR_Filter](#) (const int &Ns, [Opt_Simulator](#) *m)
- [OptSISR_Filter](#) (const int &Ns, [Gaussian_Nonlinear_Model](#) *m)

Private Attributes

- [Opt_Simulator](#) * [sim](#)

8.29.1 Constructor & Destructor Documentation

8.29.1.1 [OptSISR_Filter::OptSISR_Filter](#) (void)

8.29.1.2 [OptSISR_Filter::~~OptSISR_Filter](#) (void)

8.29.1.3 [OptSISR_Filter::OptSISR_Filter](#) (const int &Ns, [Opt_Simulator](#) *m)

8.29.1.4 [OptSISR_Filter::OptSISR_Filter](#) (const int &Ns, [Gaussian_Nonlinear_Model](#) *m)

8.29.2 Member Data Documentation

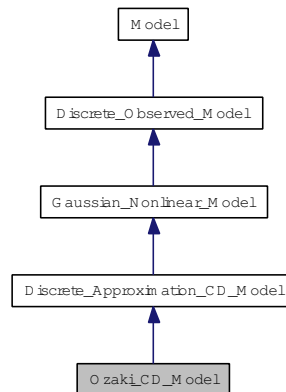
8.29.2.1 [Opt_Simulator*](#) [OptSISR_Filter::sim](#) [private]

8.30 Ozaki_CD_Model Class Reference

continuous discret model: the state SDE is discretly approximate by Ozaki method

```
#include <gaussian_model.h>
```

Inheritance diagram for Ozaki_CD_Model:



Public Member Functions

- [Ozaki_CD_Model](#) (void)
- [Ozaki_CD_Model](#) ([Continuous_Discrete_Model](#) *m, const int &a)
- dcovector [Scheme](#) (const dcovector &X, const dcovector &W)
- dgematrix [Jx_Scheme](#) (const dcovector &X, const dcovector &W)
- dgematrix [Jw_Scheme](#) (const dcovector &X, const dcovector &W)
- void [Get_Linear_Scheme](#) (const dcovector &X, const dcovector &W, dgematrix &F, dgematrix &J, dcovector &Xp)

Get the Linearized parameters Scheme in X,W.

8.30.1 Detailed Description

continuous discret model: the state SDE is discretly approximate by Ozaki method

8.30.2 Constructor & Destructor Documentation

8.30.2.1 [Ozaki_CD_Model::Ozaki_CD_Model](#) (void)

8.30.2.2 [Ozaki_CD_Model::Ozaki_CD_Model](#) ([Continuous_Discrete_Model](#) * m, const int &a)

8.30.3 Member Function Documentation

8.30.3.1 void [Ozaki_CD_Model::Get_Linear_Scheme](#) (const dcovector & X, const dcovector & W, dgematrix & F, dgematrix & J, dcovector & Xp) [virtual]

Get the Linearized parameters Scheme in X,W.

Parameters:

- X The state value
- W The noise value
- F The jacobian of $f(X,W)$ in X
- G The jacobian in $f(X,W)$ in W
- Xp The prediction $Xp = f(X,W)$

Implements [Discrete_Approximation_CD_Model](#).

8.30.3.2 dgematrix Ozaki_CD_Model::Jw_Scheme (const dcovector & X, const dcovector & W)
[virtual]

Implements [Discrete_Approximation_CD_Model](#).

8.30.3.3 dgematrix Ozaki_CD_Model::Jx_Scheme (const dcovector & X, const dcovector & W)
[virtual]

Implements [Discrete_Approximation_CD_Model](#).

8.30.3.4 dcovector Ozaki_CD_Model::Scheme (const dcovector & X, const dcovector & W)
[virtual]

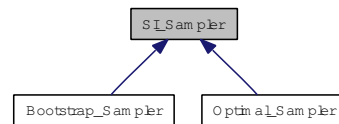
Implements [Discrete_Approximation_CD_Model](#).

8.31 SI_Sampler Class Reference

the sequential importance sampler used for sirs filter (bootstrap,optimal ...)

```
#include <sirs_filter.h>
```

Inheritance diagram for SI_Sampler:



Public Member Functions

- [SI_Sampler](#) (void)
The constructor.
- [SI_Sampler](#) (Simulator *m)
constructor
- virtual vector< [Weighted_Sample](#) > [DrawInitCloud](#) (const int &NbSample)=0
draw a set of possible init state
- virtual vector< [Weighted_Sample](#) > [Draw](#) (const dcovector &Y_k, const vector< [Weighted_Sample](#) > &X_km1)=0
Draw a set of samples from the importance density X_k given $Y_{0:k}$ $X_{0:k-1}$.
- virtual long double [Weight](#) (vector< [Weighted_Sample](#) > &cloud, const dcovector &Y_k, const vector< [Weighted_Sample](#) > &X_km1)=0
Modify the weights of cloud for the weighting step in the sirs.

Public Attributes

- [Simulator](#) * model

8.31.1 Detailed Description

the sequential importance sampler used for sirs filter (bootstrap,optimal ...)

8.31.2 Constructor & Destructor Documentation

8.31.2.1 SI_Sampler::SI_Sampler (void)

The constructor.

8.31.2.2 SI_Sampler::SI_Sampler (Simulator * *m*)

constructor

The constructor

Parameters:

m A discrete model

8.31.3 Member Function Documentation

8.31.3.1 virtual vector<Weighted_Sample > SI_Sampler::Draw (const dcovector & *Y_k*, const vector< Weighted_Sample > & *X_km1*) [pure virtual]

Draw a set of samples from the importance density X_k given $Y_{0:k}$ $X_{0:k-1}$.

Parameters:

Y_k The observation from 0 to k

X_km1 The cloud from 0 to km1

Returns:

A cloud representing the importance density $q(X_k|Y_{0:k}, X_{0:k-1})$

Implemented in [Bootstrap_Sampler](#), and [Optimal_Sampler](#).

8.31.3.2 virtual vector<Weighted_Sample > SI_Sampler::DrawInitCloud (const int & *NbSample*) [pure virtual]

draw a set of possible init state

Parameters:

NbSample Number of sample

Returns:

A set of weighted samples

Implemented in [Bootstrap_Sampler](#), and [Optimal_Sampler](#).

8.31.3.3 virtual long double SI_Sampler::Weight (vector< Weighted_Sample > & *cloud*, const dcovector & *Y_k*, const vector< Weighted_Sample > & *X_km1*) [pure virtual]

Modify the weights of cloud for the weighting step in the sisr.

Parameters:

cloud The curent coud at k

Y_k The observation at k

X_km1 the cloud from at km1

Returns:

The sum of the weights

Implemented in [Bootstrap_Sampler](#), and [Optimal_Sampler](#).

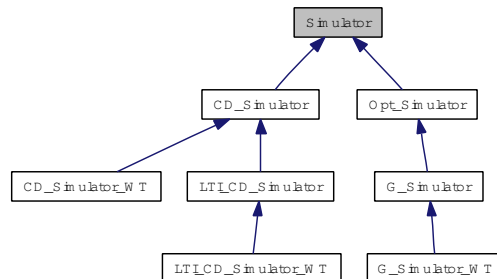
8.31.4 Member Data Documentation

8.31.4.1 Simulator* SI_Sampler::model

8.32 Simulator Class Reference

```
#include <simulator.h>
```

Inheritance diagram for Simulator:



Public Member Functions

- [Simulator](#) (void)
- [~Simulator](#) (void)
- void [Set_Seed](#) (const int &s)
- virtual dcovector [Draw_Init](#) (void)=0
Draw a sample from $p(X_0)$.
- virtual dcovector [Draw_Transition](#) (const dcovector &Xkm1)=0
Draw a sample from the transition density $p(X_k|X_{k-1})$.
- virtual dcovector [Draw_Observation](#) (const dcovector &Xk)=0
Calculate the value of the density of probability of Y given X : $p(Y|X)$.
- virtual long double [Observation_Density](#) (const dcovector &Y, const dcovector &X)=0
calculate the value of the density of probability of Y given X : $p(Y|X)$
- virtual void [Simulate](#) (const int &N)
simulate the markovian model
- virtual void [Update](#) (void)
Update the simulation of the markovian model.
- virtual int [Save_X](#) (const char *filename)
Save the simulated state trajectory in filename.
- virtual int [Save_Y](#) (const char *filename)
Save the simulated observation trajectory in filename.
- void [Clear](#) (void)
Clear the simulated trajectory X and Y .

Public Attributes

- [Model](#) * [model](#)
- vector< [dcovector](#) > [X](#)
- vector< [dcovector](#) > [Y](#)
- [dcovector](#)(* [b](#))(void *p, [gsl_rng](#) *rng)

A pointer for stochastic input.

Protected Member Functions

- virtual void [_update](#) (void)

Protected Attributes

- [gsl_rng](#) * [r](#)

8.32.1 Constructor & Destructor Documentation

8.32.1.1 [Simulator::Simulator](#) (void)

8.32.1.2 [Simulator::~~Simulator](#) (void)

8.32.2 Member Function Documentation

8.32.2.1 virtual void [Simulator::_update](#) (void) [protected, virtual]

Reimplemented in [CD_Simulator](#).

8.32.2.2 void [Simulator::Clear](#) (void)

Clear the simulated trajectory X and Y.

8.32.2.3 virtual [dcovector](#) [Simulator::Draw_Init](#) (void) [pure virtual]

Draw a sample from $p(X_0)$.

Returns:

A sample from $p(X_0)$

Implemented in [G_Simulator](#), [G_Simulator_WT](#), [CD_Simulator](#), [CD_Simulator_WT](#), and [LTI_CD_Simulator_WT](#).

8.32.2.4 virtual [dcovector](#) [Simulator::Draw_Observation](#) (const [dcovector](#) & *Xk*) [pure virtual]

Calculate the value of the density of probability of Y given X : $p(Y|X)$.

Parameters:

Xk The state at k

Returns:

The simulated observation

Implemented in [G_Simulator](#), and [CD_Simulator](#).

8.32.2.5 virtual dcovector Simulator::Draw_Transition (const dcovector & *Xkm1*) [pure virtual]

Draw a sample from the transition density $p(X_k|X_{k-1})$.

Parameters:

Xkm1 $X(k-1)$ the preceding state

Returns:

Implemented in [G_Simulator](#), and [CD_Simulator](#).

8.32.2.6 virtual long double Simulator::Observation_Density (const dcovector & *Y*, const dcovector & *X*) [pure virtual]

calculate the value of the density of probability of Y given X : $p(Y|X)$

Parameters:

Y The observation

X The state

Returns:

The value of the density

Implemented in [G_Simulator](#), and [CD_Simulator](#).

8.32.2.7 virtual int Simulator::Save_X (const char **filename*) [virtual]

Save the simulated state trajectory in filename.

Parameters:

filename The file

Returns:

0 if it's ok

Reimplemented in [CD_Simulator](#).

8.32.2.8 virtual int Simulator::Save_Y (const char **filename*) [virtual]

Save the simulated observation trajectory in filename.

Parameters:

filename The file

Returns:

0 if it's ok

Reimplemented in [CD_Simulator](#).

8.32.2.9 void Simulator::Set_Seed (const int & *s*)**8.32.2.10 virtual void Simulator::Simulate (const int & *N*) [virtual]**

simulate the markovian model

Parameters:

N The duration

X The state trajectory

Y The output

8.32.2.11 virtual void Simulator::Update (void) [virtual]

Update the simulation of the markovian model.

Parameters:

N The duration

X The state trajectory

Y The output

8.32.3 Member Data Documentation**8.32.3.1 dcovector(* Simulator::b)(void *p, gsl_rng *rng)**

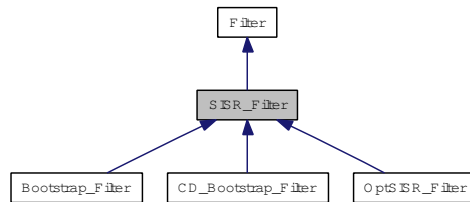
A pointer for stochastic input.

8.32.3.2 Model* Simulator::model**8.32.3.3 gsl_rng* Simulator::r [protected]****8.32.3.4 vector<dcovector> Simulator::X****8.32.3.5 vector<dcovector> Simulator::Y**

8.33 SISR_Filter Class Reference

```
#include <sisr_filter.h>
```

Inheritance diagram for SISR_Filter:



Public Member Functions

- [SISR_Filter](#) (void)
A constructor.
- [~SISR_Filter](#) (void)
The destructor.
- [SISR_Filter](#) (const int &Ns, [SI_Sampler](#) *s)
A constructor.
- [SISR_Filter](#) (const int &Ns, const double &rc, const int &seed, [SI_Sampler](#) *s)
A constructor.
- void [SetSeed](#) (const int &s)
Set the seed of the random number generator of the discret pdf.
- void [Resampling](#) (const int &Ns)
The resampling step.
- vector< [Weighted_Sample](#) > [CloudGet](#) (void)
get The current cloud
- void [SetRc](#) (const float &rc)
- dcovector [Expected_Get](#) (void)

Public Attributes

- vector< [Weighted_Sample](#) > [cloud_kml](#)
The particle clouds at kml.
- vector< [Weighted_Sample](#) > [cloud](#)
The curent particle cloud.
- int [NbSample](#)

Number of particle.

- float [Rc](#)

the resampling criterion

- [SI_Sampler](#) * [Sys](#)

the sampler

Protected Member Functions

- int [_update](#) (const dcovector &Yk)
- int [_init](#) (void)

to initialized the first particle cloud of $p(X_0)$

Protected Attributes

- gsl_rng * [r](#)
- int [seed](#)

8.33.1 Constructor & Destructor Documentation

8.33.1.1 [SISR_Filter::SISR_Filter](#) (void)

A constructor.

8.33.1.2 [SISR_Filter::~~SISR_Filter](#) (void)

The destructor.

8.33.1.3 [SISR_Filter::SISR_Filter](#) (const int & *Ns*, [SI_Sampler](#) * *s*)

A constructor.

Parameters:

Ns number of sample

s a sampler

Returns:

8.33.1.4 SISR_Filter::SISR_Filter (const int & *Ns*, const double & *rc*, const int & *seed*, SI_Sampler * *s*)

A constructor.

Parameters:

Ns number of sample
rc The resampling criterion
seed The seed
s a sampler

Returns:

8.33.2 Member Function Documentation

8.33.2.1 int SISR_Filter::_init (void) [protected, virtual]

to initialized the first particle cloud of p(X0)

Implements [Filter](#).

8.33.2.2 int SISR_Filter::_update (const dcovector & *Y*) [protected, virtual]

Specific update for each filter

Parameters:

Y The observed sample

Returns:

0 if no problem

Implements [Filter](#).

8.33.2.3 vector<Weighted_Sample> SISR_Filter::CloudGet (void)

get The current cloud

8.33.2.4 dcovector SISR_Filter::Expected_Get (void) [virtual]

Evaluate the current estimation of the state

Returns:

$\hat{X}_{k|k}$

Implements [Filter](#).

8.33.2.5 void SISR_Filter::Resampling (const int & *Ns*)

The resampling step.

Parameters:

Ns

8.33.2.6 void SISR_Filter::SetRc (const float & *rc*)

Set the Resampling Criterion

Parameters:

rc The resampling Criterion

8.33.2.7 void SISR_Filter::SetSeed (const int & *s*)

Set the seed of the random number generator of the discret pdf.

Parameters:

s The seed

8.33.3 Member Data Documentation**8.33.3.1 vector<Weighted_Sample > SISR_Filter::cloud**

The current particle cloud.

8.33.3.2 vector<Weighted_Sample > SISR_Filter::cloud_km1

The particle clouds at km1.

8.33.3.3 int SISR_Filter::NbSample

Number of particle.

8.33.3.4 gsl_rng* SISR_Filter::r [protected]**8.33.3.5 float SISR_Filter::Rc**

the resampling criterion

8.33.3.6 int SISR_Filter::seed [protected]**8.33.3.7 SI_Sampler* SISR_Filter::Sys**

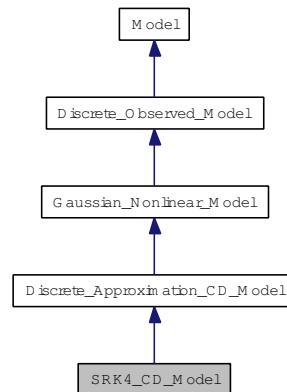
the sampler

8.34 SRK4_CD_Model Class Reference

continuous discret model: the state SDE is discretly approximate by an Sstochastic runge kutta method

```
#include <gaussian_model.h>
```

Inheritance diagram for SRK4_CD_Model:



Public Member Functions

- [SRK4_CD_Model](#) (void)
- [SRK4_CD_Model](#) ([Continuous_Discrete_Model](#) *m, const int &a)
- dcovector [Scheme](#) (const dcovector &X, const dcovector &W)
- void [Get_Linear_Scheme](#) (const dcovector &X, const dcovector &W, dgematrix &F, dgematrix &J, dcovector &Xp)

Get the Linearized parameters Scheme in X,W.

- dgematrix [Jx_Scheme](#) (const dcovector &X, const dcovector &W)
- dgematrix [Jw_Scheme](#) (const dcovector &X, const dcovector &W)

8.34.1 Detailed Description

continuous discret model: the state SDE is discretly approximate by an Sstochastic runge kutta method

8.34.2 Constructor & Destructor Documentation

8.34.2.1 [SRK4_CD_Model::SRK4_CD_Model](#) (void)

8.34.2.2 [SRK4_CD_Model::SRK4_CD_Model](#) ([Continuous_Discrete_Model](#) * m, const int &a)

8.34.3 Member Function Documentation

8.34.3.1 void [SRK4_CD_Model::Get_Linear_Scheme](#) (const dcovector & X, const dcovector & W, dgematrix & F, dgematrix & J, dcovector & Xp) [virtual]

Get the Linearized parameters Scheme in X,W.

Parameters:

- X The state value
- W The noise value
- F The jacobian of $f(X,W)$ in X
- G The jacobian in $f(X,W)$ in W
- Xp The prediction $Xp = f(X,W)$

Implements [Discrete_Approximation_CD_Model](#).

8.34.3.2 `dgematrix SRK4_CD_Model::Jw_Scheme (const dcovector & X, const dcovector & W)`
[virtual]

Implements [Discrete_Approximation_CD_Model](#).

8.34.3.3 `dgematrix SRK4_CD_Model::Jx_Scheme (const dcovector & X, const dcovector & W)`
[virtual]

Implements [Discrete_Approximation_CD_Model](#).

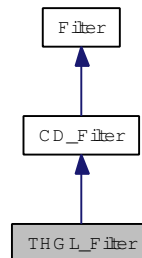
8.34.3.4 `dcovector SRK4_CD_Model::Scheme (const dcovector & X, const dcovector & W)`
[virtual]

Implements [Discrete_Approximation_CD_Model](#).

8.35 THGL_Filter Class Reference

```
#include <thgl_filter.h>
```

Inheritance diagram for THGL_Filter:



Public Member Functions

- [THGL_Filter](#) (void)
- [THGL_Filter](#) ([Continuous_Discrete_Model](#) *m)

Protected Member Functions

- [int _update](#) (const [dcovector](#) &Y)

8.35.1 Constructor & Destructor Documentation

8.35.1.1 [THGL_Filter::THGL_Filter](#) (void)

8.35.1.2 [THGL_Filter::THGL_Filter](#) ([Continuous_Discrete_Model](#) * *m*)

8.35.2 Member Function Documentation

8.35.2.1 [int THGL_Filter::_update](#) (const [dcovector](#) & *Y*) [[protected](#), [virtual](#)]

Specific update for each filter

Parameters:

Y The observed sample

Returns:

0 if no problem

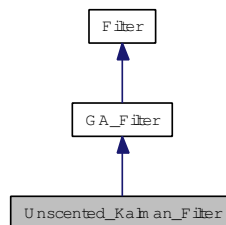
Implements [Filter](#).

8.36 Unscented_Kalman_Filter Class Reference

The Discrete Unscented Kalman [Filter](#) (UKF).

```
#include <unscented_kalman_filter.h>
```

Inheritance diagram for Unscented_Kalman_Filter:



Public Member Functions

- [Unscented_Kalman_Filter](#) (void)
A constructor.
- [Unscented_Kalman_Filter](#) ([Gaussian_Nonlinear_Model](#) *model)
The constructor.

Public Attributes

- float [lambda](#)
A scaled parameter.

Protected Member Functions

- int [SP_Init](#) (void)
Initialize the sigma points at each update step.
- int [U_Cov](#) (const vector< dcovector > &sP1, const dcovector &m1, const vector< dcovector > &sP2, const dcovector &m2, dgematrix &cov)
Calculate the covaraince between two sets of sigma points.
- int [U_Mean](#) (const vector< dcovector > &sP, dcovector &mean)
Calculate the mean of a set of sigma points.
- int [_update](#) (const dcovector &Y)
- int [_init](#) (void)
Itialization of the UKF.

Private Attributes

- dgematrix [sqrt_Qw](#)
The square root matrix (cholesky) of Q_w .
- dgematrix [sqrt_Qv](#)
The square root matrix (cholesky) of Q_v .
- vector< dcovector > [sX](#)
The sigma points for the state X .
- vector< dcovector > [sW](#)
The sigma points for the state noise W .
- vector< dcovector > [sY](#)
The sigma points for the observation.
- double [w_0](#)
The first weight to compute the mean.
- double [w_0c](#)
The first weight to compute the covariance.
- double [w](#)
Other weights.

8.36.1 Detailed Description

The Discrete Unscented Kalman [Filter](#) (UKF).

8.36.2 Constructor & Destructor Documentation

8.36.2.1 Unscented_Kalman_Filter::Unscented_Kalman_Filter (void)

A constructor.

8.36.2.2 Unscented_Kalman_Filter::Unscented_Kalman_Filter (Gaussian_Nonlinear_Model **model*)

The constructor.

Parameters:

model A gaussian non linear model

8.36.3 Member Function Documentation

8.36.3.1 `int Unscented_Kalman_Filter::_init (void)` [protected, virtual]

Itialization of the UKF.

Reimplemented from [GA_Filter](#).

8.36.3.2 `int Unscented_Kalman_Filter::_update (const dcovector & Y)` [protected, virtual]

Specific update for each filter

Parameters:

Y The observed sample

Returns:

0 if no problem

Implements [Filter](#).

8.36.3.3 `int Unscented_Kalman_Filter::SP_Init (void)` [protected]

Initialize the sigma points at each update step.

8.36.3.4 `int Unscented_Kalman_Filter::U_Cov (const vector< dcovector > & sP1, const dcovector & m1, const vector< dcovector > & sP2, const dcovector & m2, dgematrix & cov)` [protected]

Calculate the covaraince between two sets of sigma points.

Parameters:

sP1 The first set of sigma point

m1 The mean of the sigma point

sP2 The second set of sigma point

m2 The mean of the second set of sigma point

cov Return the empirical covariance matrix between two sets

Returns:

0 if dimensions are ok

8.36.3.5 `int Unscented_Kalman_Filter::U_Mean (const vector< dcovector > & sP, dcovector & mean)` [protected]

Calculate the mean of a set of sigma points.

Parameters:

sP a set of sigma point

mean Return the mean

Returns:

0 if dimensions are ok

8.36.4 Member Data Documentation**8.36.4.1 float Unscented_Kalman_Filter::lambda**

A scaled parameter.

8.36.4.2 dgematrix Unscented_Kalman_Filter::sqrt_Qv [private]

The square root matrix (cholesky) of Qv.

8.36.4.3 dgematrix Unscented_Kalman_Filter::sqrt_Qw [private]

The square root matrix (cholesky) of Qw.

8.36.4.4 vector<dcovector> Unscented_Kalman_Filter::sW [private]

The sigma points for the state noise W.

8.36.4.5 vector<dcovector> Unscented_Kalman_Filter::sX [private]

The sigma points for the state X.

8.36.4.6 vector<dcovector> Unscented_Kalman_Filter::sY [private]

The sigma points for the observation.

8.36.4.7 double Unscented_Kalman_Filter::w [private]

Other weights.

8.36.4.8 double Unscented_Kalman_Filter::w_0 [private]

The first weight to compute the mean.

8.36.4.9 double Unscented_Kalman_Filter::w_0c [private]

The first weight to compute the covariance.

8.37 Weighted_Sample Class Reference

```
#include <sisr_filter.h>
```

Public Attributes

- dcovector [Value](#)
The position.
- long double [Weight](#)
The weight of the sample.

8.37.1 Member Data Documentation

8.37.1.1 dcovector Weighted_Sample::Value

The position.

8.37.1.2 long double Weighted_Sample::Weight

The weight of the sample.

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