Continuous Constraint Programming

The C++ library for constraint processing over real numbers. First steps.

1. The Interval-Based EXplorer library (IBEX): http://www.ibex-lib.org/

a) Download the latest release (http://www.ibex-lib.org/download) and install in your working environment (http://www.ibex-lib.org/doc/install.html).
b) Test with a simple problem (http://www.ibex-lib.org/doc/install.html#compiling-a-test-program).
c) Install the graphical tool: Vibes (https://github.com/ENSTABretagneRobotics/VIBES). Use the pre-built binaries of the VIBes viewer provided for Windows, MacOS and Linux platforms (https://github.com/ENSTABretagneRobotics/VIBES/releases).
d) Test with the example1.cpp problem (extracted from the examples provided in the IBEX library).

2. Graphics, Boxes and Contractors

Consider the problem presented in the theoretical classes:

$$x \in [-2,2] \quad y \in [-2,10]$$
$$y = x^2 \qquad y \geq 2x + 4$$

Use program example2.cpp to:

a) Draw the graphics for $y = x^2$ and $y = 2x + 4$.
b) Draw the initial box.
c) Draw the box resulting from contracting the initial box only wrt the constraint $y = x^2$.
d) Draw the box resulting from contracting the initial box only wrt the constraint $y \geq 2x + 4$.
e) Draw the box resulting from contracting the initial box by propagating the contraction of both constraints.
f) Draw the two boxes resulting from the application of the propagation contractor to both boxes obtained from splitting the largest domain of the previous box.

3. System Solver and Global Optimizer

Consider the problem presented in the theoretical classes:

$$x \in [-\pi, \pi] \quad x \in [-\pi, \pi]$$
$$x^2y + xy^2 \leq 0.5$$

Use program example3.cpp to:

a) Call the system solver IbexSolve to compute a cover of the solution space from the specification in file satisfaction_problem.txt.
b) Call the global optimizer IbexOpt to search for a solution that maximizes $x + y$. The respective minimization problem is specified in file optimization_problem.txt.

4. The Problem of the Seismic Epicentre

Consider the problem where the goal is to estimate the epicentre coordinates of a seismic event. The seismic waves produced have been recorded at a network of six seismic stations at different arrival times. The following table presents their coordinates and the observed arrival times.

(x_i, y_i)	(3 km,15 km)	(3 km,16 km)	(4 km,15 km)	(4 km,16 km)	(5 km,15 km)	(5 km,16 km)
t_i	3.12 s	3.26 s	2.98 s	3.12 s	2.84 s	2.98 s

It is assumed that: seismic waves travel at a constant velocity of $v = 5\ km/s$; experimental uncertainties on the arrival times are independent and can be modelled using a Gaussian probability density with a standard deviation $\sigma = 0.1\ s$.

a) Compute a cover of the possible epicentre coordinates of the seismic event assuming that the observation errors cannot exceed 3σ.
b) Compute the maximum likelihood point, that is, the epicentre coordinates that minimizes the sum of the squared errors.
c) Show graphically the results obtained.