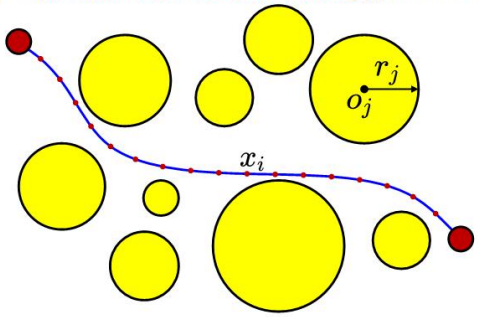
Numerical Optimization in Robotics

Homework_2 Instruction

1. Smooth Navigation Path Generation

Cubic Spline (Minimum Stretch Energy) Path Generation



Complete the smooth path generation by unconstrained minimization:

$$\min_{x_1,x_2\ldots,x_{N-1}} \text{Energy}(x_1, x_2 \ldots, x_{N-1}) + \text{Potential}(x_1, x_2 \ldots, x_{N-1})$$

The non-smooth path can provide an initial guess for decision variables.

You have to implement Broyden-Fletcher-Goldfarb-Shanno(BFGS) to optimize the trajectory by minimum the objective function given above and the constraints of the optimization problem are the obstacle in the environment.

2. Problem analysis

Cubic Spline: Cubic spline interpolation is a special case for Spline interpolation that is used very often to avoid the problem of Runge's phenomenon. This method gives an interpolating polynomial that is smoother and has smaller error than some other interpolating polynomials such as Lagrange polynomial and Newton polynomial.

For more: *https://mathworld.wolfram.com/CubicSpline.html*

https://en.wikiversity.org/wiki/Cubic_Spline_Interpolation

Broyden-Fletcher-Goldfarb-Shanno (BFGS) algorithm: You can find details in the course.

Trajectory planning : here is a great survey paper for you.'***Survey of UAV motion planning***'.

For more: you can find more details in the reference book.

3. Assignment requirements

- ✓ Your homework ***should*** be a ***zip*** including your code, an documentation and an instruction.
- ✓ You ***should*** complete the homework in the given framework which means you have to finish it in C++.
- ✓ You ***must*** given an instruction named ***'readme'*** to tell the reader how to run your code and check your answer.

- ✓ You ***have to*** give an report for this assignment which includes (1) the ***workflow and result*** of your homework; (2) your ***analysis*** of the homework; (3) any ***question or suggestion*** of the course and the homework.
- ✓ You can add your notes of this course to your homework.

4. Scoring Criteria

Unqualified: The results are incorrect, or the assignment is not written in the required format.

Qualified: The results are somewhat different from the standard results, but there is a correct knowledge and understanding of the assignment requirements.

Good: The homework complete the code and make the program work.

OutStanding: The program can generate a smooth and collision-free trajectory.

Bachelor of Science ETH in Elektrotechnik und Informationstechnologie
6 Semester

Grundstudium (1. – 4. Semester)
1. + 2. Semester, Basisjahr

Mathematik (25 KP) – Analysis I, II – Lineare Algebra – Komplexe Analysis	**Elektrotechnik** (16 KP) – Netzwerke und Schaltungen I, II – Digitaltechnik	**Physik** (8 KP) – Technische Mechanik – Physik I	**Informatik** (4 KP) – Informatik I	**Praktika-Projekte-Seminare** (3 KP) – Informatikpraktikum – Obligatorische Praktika

3. + 4. Semester

Mathematik (16 KP) – Analysis III – Diskrete Mathematik – Numerische Methoden – Wahrscheinlichkeits-theorie und Statistik	**Elektrotechnik** (20 KP) – Halbleiter-Schaltungs-technik – Halbleiterbauelemente – Signal- und System-theorie I, II – Elektromagnetische Felder und Wellen	**Physik** (8 KP) – Physik II	**Informatik** (8 KP) – Informatik II – Technische Informatik	**Praktika-Projekte-Seminare** (7 KP) – Obligatorisches Praktikum – wählbare Projekte und Seminare

Vertiefung
5. + 6. Semester

Kernfächer und weitere Grundlagenfächer (mind. 18 + 8 KP) Auswahl aus den zentralen Bereichen der Elektrotechnik und Informationstechnologie	**Wahlfächer** (mind. 6 KP) Auswahl aus dem gesamten Angebot der ETH	**Science in Perspective** (6 KP) Auswahl von Fächern aus Geistes-, Sozial- und Staatswissenschaften (D-GESS)	**Praktika-Projekte-Seminare** (ca. 10 KP) wählbare Praktika, Projekte und Seminare (z. B. Gruppenarbeiten)	**Bachelor-Arbeit** (12 KP)