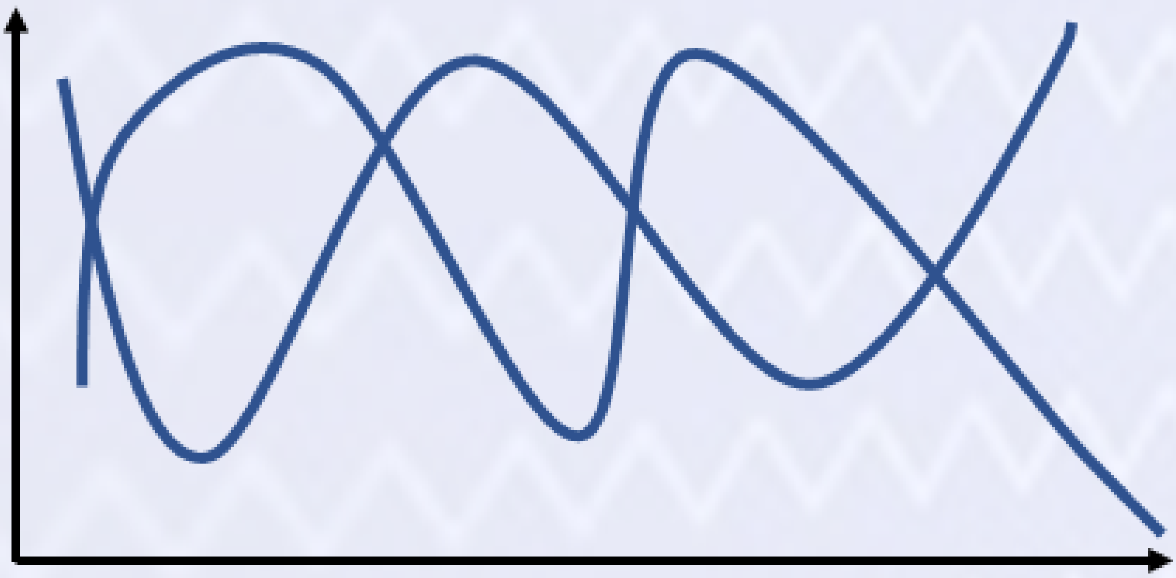
SIAM Student Chapter Delft

Delft University of Technology

Workshop Day 2020

October 15, 2020

Non-linear Equations



Student Chapter at TU Delft

Society for Industrial and Applied Mathematics

DCSE

Enabling Technology for Industry

TU Delft

Introduction

The SIAM Student Chapter of TU Delft has been founded in 2014 by PhD students of the Numerical Analysis section. Every year the chapter organizes a workshop day on a topic in applied mathematics. The workshop day aims to bring together colleagues working in similar fields to share their current research. This year the topic of the workshop day is 'Non-linear Equations'.

More details on the chapter and previous workshop days can be found on the following link.

https://sscdelft.github.io/

You can also scan the following barcode for more details.

Organizing committee

Prof. Dr. Ir. Kees Vuik	**Dr. Ir. Martin van Gijzen**	**Roel Tielen**
(Faculty advisor)	(Faculty advisor)	(BaNaNa Officer)
Qiyao Peng	**Prajakta Nakate**	**Linlin Bu**
(President)	(Vice President and Secretary)	(Treasurer)

Timetable

Thursday, October 15

10.30-10.40	Opening and Introduction to SIAM-SC
10.40-11.25	Non-linear equations in Finance: **Prof.dr.ir.C.W.Oosterlee**
11.25-11.50	Non-linear equations in Finance: **B. Boonstra**
11.50-12.20	BaNaNa Talk: **H.M. Verhelst** (G+smo and Kirchov-Love shells)
12.20-13.00	Lunch Break
13.00-13.45	Non-linear equations in combustion: **Dr. B. Cuenot**
13.45-14.10	Non-linear equations in combustion: **R. Sampat**
14.10-14.25	Coffee Break
14.25-15.10	Non-linear equations in power flow: **Dr.ir. J.L.Rueda Torres**
15.10-15.35	Non-linear equations in power flow: **Dr.ir. B.Sereteer**
15.35-15.45	End

List of Abstracts – Talks

Non-linear Equations in Finance

The modelling of American Options

Prof.dr.ir. C. W. Oosterlee

Delft University of Technology, The Netherlands

In this presentation, we'll discuss the basic nonlinear partial differential equation in the option pricing context, which is the American option. A financial option gives the right to buy or sell a stock S in the future, for a pre-determined price K. A put option, for example, gives to right to sell a stock for the price K.

So-called European options can only be "exercised" at the contract's final time T, however, an American option can be exercised at any time before the contract's final time T. The decision about the optimal exercise time makes this option pricing equation nonlinear, as we'll show in the presentation. After a basic example, we'll discuss the concept of obstacle problem to solve this special nonlinear PDE as a linear complementarity problem.

In my group, we'll however solve such problems with the COS method or with Monte Carlo methods, and we'll outline the contours of such pricing methods in the talk too.

Non-linear Equations in Finance

Valuation of the Bermudan option and the electricity storage contract

Boris Boonstra

CWI, The Netherlands

In this presentation we will introduce a numerical pricing technique, the well-known COS method, to solve the nonlinear dynamic programming formulation of the Bermudan option. In addition to the Bermudan option, the electricity storage contract is discussed and priced with the COS method. The electricity storage contract is a contract where electricity can be sold/bought at fixed moments in time by trading on the electricity market in order to make a profit while the energy level in the storage changes. For example, an application of the electricity storage contract is to investigate whether a parking lot with electric cars can be utilized to make a profit by trading on the electricity market, by using the batteries of the stationary cars.

The main idea of the COS method is to approximate the conditional probability density function via the Fourier cosine expansion and make use of the relation between the coefficients of the Fourier cosine expansion and the characteristic function. The use of the characteristic function is convenient, because the density function is often unknown for relevant asset processes, in contrast to the characteristic function.

BaNaNa Talk

Implementation of nonlinear isogeometric Kirchhoff-Love shell models in G+Smo

Hugo Verhelst

Delft University of Technology, The Netherlands

The Kirchhoff-Love shell formulation is used in many engineering applications, where the thickness of the shell relative to a particular length dimension is very small (a factor 100 smaller). In these cases, the Kirchhoff hypothesis is satisfied, stating that the shell can be modelled by its mid-plane geometry and that shear effects are neglected. The formulation, however, involves bending and membrane strain terms. In this talk, we will consider the Kirchhoff-Love equations for thin shells and its implementation. After briefly deriving the variational formulation related to this problem, we will have a detailed look at implementation aspects when using B-spline basis functions. In particular, we will have a look at the Expression Assembler framework from G+Smo and the implementation of the Kirchhoff-Love shells herein. Nonlinearities related to large deformations, loads and materials will be treated as well.

Non-linear Equations in Combustion

Numerical simulation of turbulent combustion

Dr. Benedicte Cuenot

CERFACS/CFD, France

Combustion is today, and by far, the main source of energy and the basis of our modern way of life. Replacing combustion with renewable energy (solar or wind) is still out of reach unless drastically reducing our consumption or increasing nuclear energy. It has however two major drawbacks: the use of fossil fuel, which by definition will come to an end, and the emission of pollutants which are toxic for human health and contribute to the climate change. It is therefore critical to develop combustion processes and systems that reduce or even suppress these problems. Combustion is the combination of chemistry and fluid mechanics, and therefore contains many non-linearities. The presentation will review these linearities and their interactions. An overview of the main resolution techniques used today will be given, as well as of the current research on new numerical approaches. Examples of applications will be finally given to illustrate the state-of-the-art of numerical combustion.

Non-linear Equations in Combustion

Automatic Generation of Chemical Reactor Networks for Combustion Simulations

Rishikesh Sampat

Delft University of Technology, The Netherlands

Flameless combustion is a regime that is capable of giving very low nitrogen oxide(NOx) emissions. Predicting NOx through numerical calculations remains a challenge mainly because of the requirement of detailed chemical mechanisms which can prove to be very costly in computational fluid dynamics(CFD). Combustion simulations entail the solution of non-linear equations not only because of the flow field but also because of the stiff, non-linear equations of the chemical reaction mechanism. Researchers in the past have used CFD-CRN methods to combine capabilities of CFD to calculate the flow field using simplified chemistry and Chemical Reactor Networks(CRN) to incorporate detailed chemical reaction mechanisms cost effectively. However, the CRN is either defined manually or generated in a case specific manner. We have developed a CFD-CRN tool, AGNES, that can automatically generate a CRN from the CFD domain based on user input criteria. A breadth-first search algorithm is used to cluster the CFD cells into a CRN and the resultant is solved in a custom built solver based on existing libraries of Cantera and SciPy. The tool is applied to a test case of a non-premixed flameless combustor and the abilities of the tool are exploited to study the NOx production reaction-pathways in the combustion chamber.

Non-linear Equations in Power Flow

Optimization Problems in Operation and Planning of Electrical Power Systems

Dr.ir. J.L.Rueda Torres

Delft University of Technology, The Netherlands

The operation and planning of sustainable electrical power systems faces several challenges, like modified steady-state and dynamic properties, and high uncertainty due to the variability and high share of renewable power generation and random variations of demand and ancillary service providers. The different types of optimization problems defined for different applications in operation and planning are hard-to-solve due to the necessity of considering a large number of aspects, like probabilistic models that represent uncertain variables, combined with the complexity of a search space defined by non-linear equations modelling the physical system performance, as well as special problem properties like non-convexity, discontinuity and multi-modality. This presentation will overview several formulations of optimization problems concerning with the steady-state and dynamic performance of electrical power systems. Example case studies of tests beds developed within the scope of the IEEE PES Working Group on Modern Heuristic Optimization (https://site.ieee.org/psace-mho/) will be discussed.

Non-linear Equations in Power Flow

Solving the non-linear power flow equations using the physical properties of the power system

Dr.ir. B.Sereteer

TJIP B.V., The Netherlands

The power flow (PF), or load flow, problem is the problem of computing the voltages in each bus of a power system where the power generation and consumption are given. Mathematically, the power flow problem comes down to solving a nonlinear system of equations where all variables are given in complex numbers. In practice, the Newton power flow method using the power balance equations in polar coordinates is preferred in terms of quadratic convergence. In order to obtain the required fast and robust PF solution method for an changing electrical power system, we examine all six formulations of the PF problem using two different mismatch formulations: the current and power balance equations, and three different coordinate systems: Cartesian, polar, and complex form. Moreover, we develop new versions of the Newton power flow method based on all six formulations of the PF problem. Our newly developed versions are compared with the existing variants of the Newton power flow method for both balanced single-phase and unbalanced three-phase networks in terms of the computational speed and robustness. Two Newton power flow variants developed in this research work are proven to be faster and more robust than the existing Newton power flow methods. Furthermore, we introduce the new approach to linearize the original nonlinear PF problem using the connection between actual buses in the network to artificial ground buses. Direct and iterative methods are developed to solve the resulting Linear Power Flow (LPF) problem.