Numerical Maths

isakhammer

A20

Contents

1 Lecture 1

1.1 Practical Information

- Brynjulf Owren, room 1350, Sentralbygg 2, brynjulf.owren@ntnu.no
- Alvar Lindell, room 1201, Sentralbygg 2, alvar.lindell@ntnu.no

There will be a total of 6 assignment where 4 should be approved. It should be delivered in blackboard as a jupyter notebook file including some control questions.

- **Project 1** It counts 10 procent on the final grade, relativaly small work, but somewhat large assignment. Every student submits her own separate .ipynb file. Discuss problem if you like, but make your own write-up. Likely to be a topic of algebra. Deadline. 10-15 September.
- **Project 2** Counts 20 procent on the final grade. Group project 1-3 students. Numerical ODE and may some optimization.

Lecture contents of the course

- Introduction 3.6%
- Numerical linear algebra 21.4%
- Numerical ODE 28.6%
- Nonlinear Systems and Numerical Optization 7.1%

May be jupyter programming on the exam.

1.2 M2 Basic Linear Algebra

1.2.1 Background summary

Vectors. Most of the time we think of vectors as n-plets of real numbers.

$$v = \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{bmatrix}$$

Vecotrs are columns vectors if row vectors are needed use.

$$v^T = \begin{bmatrix} v_1 & v_2 & v_3 & \dots & v_n \end{bmatrix}$$

Linear Transformations are given by $A : \mathbb{R}^n \to \mathbb{R}^m$. These are represented ass $m \times n$ matrices. $A = ((a_{ij}))$ such that $1 \leq i \leq m$ and $1 \leq j \leq n$. Notation $A \in \mathbb{R}^{m \times n}$

$$(Av)_i = \sum_{j=1}^{n} a_{ij} v_j, \quad i = 1, \dots, m.$$

If $A = ((a_{ij}))$, B $((b_{ij}))$ then $A + B = C$, $C = ((c_{ij}))$, $c_{ij} = a_{ij} + b_{ij}$.
Given to matrices, $A \in \mathbb{R}^{m\times k}$ and $B \in \mathbb{R}^{k\times n}$

$$\mathbb{R}^n \to \mathbb{R}^k \to \mathbb{R}^m$$

$$\mathbb{R}^n \to \mathbb{R}^m$$

$$(A \cdot B)_{ij} = \sum_{r=1}^{k} a_{ir} b_{ri}$$

Fix a way to have notation on top of arrow and a better snippet for the summation. Might also train making quick vector notations.

1.2.2 Linear Independence

Let assume that we have $v_1, \ldots, v_k$ be vectors in $\mathbb{R}^n$ and let $\alpha_1, \alpha_2, \ldots, \alpha_k$ be scalar if

$$\sum_{n=1}^{k} \alpha_i v_i = 0 \quad \text{then is} \quad \alpha_1 = \alpha_2 = \ldots = 0$$

Then $v_1, v_2, \ldots, v_k$ is linear independent.

1.2.3 Inverse of an $n \times n$ matrix

If there is a matrix $B \in \mathbb{R}^{n\times n}$ such that

$$A \cdot B = B \cdot A = I$$

Then B is the inverse of A. B is denoted $B = A^{-1}$ Basis of $\mathbb{R}^n$. Any set of n linearly independent vectors in $\mathbb{R}^n$ is called a basis.

1.2.4 Permutation Matrix

Permuation Matrix. Let $I \in \mathbb{R}^{n\times n}$ be the identity matrix. I has columns $e_1, e_2, \ldots, e_n$ where e_i is the i-th canonical unit vector

$$\begin{bmatrix} 0 & 0 & \ldots 1 \ldots 0 \end{bmatrix} = e^T$$

Let $p = \begin{bmatrix} i_1, i_2, \ldots, i_n \end{bmatrix}^T$ Be a permutation of the set $\{1, \ldots, n\}$ then

$$P = \begin{bmatrix} e_1 & e_2 & e_2 \end{bmatrix}$$

The permutation metrix.

Implement example snippet

The inverse of a permutation matrix in $P^{-1} = P^T$ and $\left(P^{-1}\right)_{ij} = P_{ji}$.

1.2.5 Types of Matrices

- Symmetric: $A^T = A$
- Skew symmetric: $A^T = -A$
- Orthogonal. $A^T A = I$