TP Session Report: Convex Functions, Convex Sets and Relations between Sets using MATLAB

Mathematics Department

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Objective of the Session

The aim of this session is to help students understand the concepts of convex functions and convex sets, and to explore some fundamental operations on sets such as union, intersection and difference. MATLAB is used as a computational tool to visualize sets, check convexity conditions, and perform set operations.

Convex Functions

A function $f : \mathbb{R}^n \to \mathbb{R}$ is convex if

$$f(\lambda x + (1-\lambda)y) \leq \lambda f(x) + (1-\lambda)f(y), \quad \forall x, y \in \mathbb{R}^n,\ \lambda \in [0,1].$$

In practice, convexity can be tested by checking if the Hessian matrix of f is positive semidefinite.

MATLAB Commands:

```
syms x y
f = x^2 + y^2;
hessian(f, [x y])  % compute Hessian
```

Convex Sets

A set $C \subset \mathbb{R}^n$ is convex if for any $x, y \in C$ and $\lambda \in [0,1]$, we have

$$\lambda x + (1-\lambda)y \in C.$$

MATLAB Commands:

```
ezplot('x^2 + y^2 <= 1')   % plot a convex set (disk)
```

Relations Between Sets

Students also explore classical set operations using MATLAB, such as union, intersection, difference, and inclusion.

MATLAB Commands:

```
A = [1 2 3 4 5];
B = [3 4 5 6];
union(A,B)          % Union
intersect(A,B)      % Intersection
setdiff(A,B)        % Difference A\B
ismember(2,A)       % Check inclusion
```

Conclusion

This TP session provides students with a practical introduction to convex analysis and set theory using MATLAB. Visualization and symbolic computation allow students to confirm theoretical results and deepen their understanding of convexity and set relations.

Keywords

Convex function, Convex set, Hessian matrix, MATLAB, Set operations, Union, Intersection, Difference.