Closed-Form Expressions of Convex Combinations with Application in Control

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Background

Convex combinations are used to express a point in a set as a weighted sum of the extreme points of this set. Therefore, convex combinations are used in many different applications, including control. When controlling linear parameter varying systems which are affected by disturbances, there exist robust control algorithms [1] which use convex combinations to interpolate between extreme controllers depending on the current disturbance. These controllers are used for example for space shuttles which are affected by wind and electromagnetic interferences, but also helicopters, wind power plants, and robotic manipulators, etc.

For all these applications it is important to obtain the parameters of the convex combination very fast. Instead of solving a system of inequalities, a closed-form expression is required which can easily be evaluated. These closed-form expressions are also necessary when trying to prove the safety of these controllers, which is important for safety-critical applications.

Therefore, we presented in [2] several algorithms to obtain closed-form expressions of convex combinations for different shapes of sets, which can be used to improve the previously mentioned control problems and are useful in many other applications as well. Besides the approaches in [2], there exist some other approaches for obtaining convex combinations for certain sets. The goal of this thesis is to obtain an overview of existing approaches and to compare those methods.

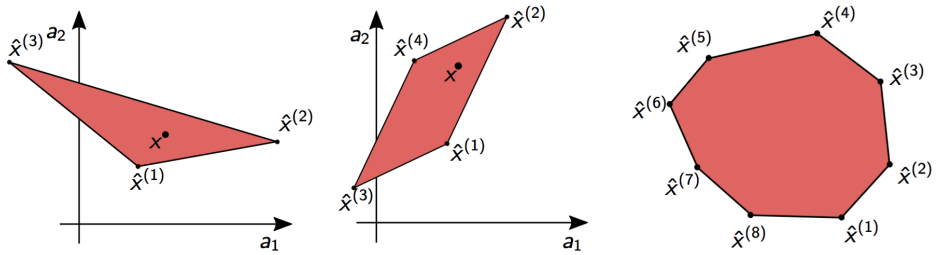

Illustration of the different shapes of sets for which closed-form expressions of convex combinations exist in [2].

Tasks

- Literature review about existing methods
- Comparison of the complexity of different methods
- Implementing the algorithms as efficiently as possible
- Comparison of run times of different algorithms
- Improve existing algorithms and develop new approaches
- Test algorithms for application examples

This topic offers a wide variety of both theoretical and practical elements, where you are able to apply the skills you learned during your studies to an interesting problem. The results have a direct impact in many fields, including robust control.

References

[1] Pierre Apkarian, Pascal Gahinet, and Greg Becker. Self-scheduled H-infinity control of linear parameter-varying systems: a design example. *Automatica*, 31(9):1251–1261, 1995.

[2] Bastian Schürmann, Ahmed El-Guindy, and Matthias Althoff. Closed-form expressions of convex combinations. In *Proc. of the American Control Conference*, pages 2795–2801, 2016.

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Research project:
UnCoVerCPS

Type:
BA/MA

Research area:
Convex Combinations, Polytopes, LPV control

Programming language:
MATLAB

Required skills:
Good knowledge of mathematics. Experience with Matlab is helpful.

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German/English

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