Icelandic Research Fund
Application: 218170-051

1.1 Title and abstract

Title in English

Extending the Combex framework

Title in Icelandic

Útvíkkun á Combex-aðferðinni

Acronym

Combex

Abstract In English

We propose to continue the development of the Combex framework, a framework that can leverage domain-specific knowledge to rigorously derives structural results about mathematical objects. It works by first creating a universe of rules about the original objects and then looking for a specification describing the object. By adding domain-specific knowledge from the field of permutation patterns, the PermScope algorithm prototype was created. This algorithm proved to be a very powerful tool to enumerate permutation classes and was able discovered new theorems and rediscovered results spanning dozens of papers in the literature.

The proposer will work on improving the Combex framework and the PermScope algorithm. He will implement iterative deepening search using machine learning to make the search of the Combex framework more efficient. The PhD student will also add the capacity to track permutation statistics to the PermScope algorithm. Finally, he will develop algorithm to find combinatorial systems using combinatorial exploration.

The outcome of this proposal includes publications in journals and presentations at international conferences. The implementations of these theoretical algorithms will be made available open source.

Abstract In Icelandic

Við leggjum til áframhaldandi þróun á umhverfi sem getur nýtt sérhæfða þekkingu til þess að uppgötva og sanna fræðisetningar á fjölmörgum sviðum stærðfræðinnar.

Fléttufræðileg könnun er tilraunakennd aðferð sem leyfir nákvæma útleiðslu á uppbyggingu stærðfræðilegra fyrirbæra. Þegar manneskja hefur fundið uppbyggingu hlutar eru til ýmsar aðferðir til að reikna út eiginleika hlutarins. Hinsvegar eru skrefin frá upphaflega vandamálinu að uppbyggingunni oft handahófskennd. Það er þetta bil sem við ætlum að brúa.

Með aðferðum úr fléttufræði, tölvualgebru og algebrulegri rúmfræði höfum við útfært frumgerð af umhverfinu. Með því að bæta við sérhæfðri þekkingu úr sviði umraðanamynstra við frumgerðina bjuggum við til reiknirit sem hefur uppgötvað nýjar fræðisetningar og enduruppgötvað niðustöður sem spanna fjölmargar greinar í fræðunum.

Við leggjum til að nýta aðferðir úr vélrænu gagnanámi til að bæta frumgerðina, beita henni á fleiri vandamál í umraðanamynstrum, sem og að bæta við aðferðum til að rannsaka ýmsar mismunandi fléttufræðilegar fjölskyldur.

Útkoman úr þessarri tillögur verða birtingar í tímaritum og ráðstefnum á alþjóðlegum vettvangi. Útfærslurnar á fræðilegu reikniritunum verða gefnar út frítt.

Has the proposal previously been submitted to IRF? Yes

Explain any changes from previous proposal

Some work packets have been removed since the proposal was shortened from 3 to 2 years. Also, more emphasis is put on combinatorial systems. The proposal was reworked to explain the concept in more details and make it easier to follow.

Is there another proposal for grant year 2021 that includes wages for the doctoral student? No

1.2 Expert Panel assignment

Specify the expert panel you wish to review your application	Physical sciences and mathematics
Expert Panel	Mathematics
Other Scientific category	Computer sciences
Keywords in English	combinatorics, algorithm, permutation patterns, machine learning
Keywords in Icelandic	fléttufræði, reiknirit, umraðanamynstur, vélrænt gagnanám

1.3 Non-Preferred Reviewer

Non-Preferred reviewer

Name or ID*

Affiliation

Reason for request

1.4 Project Accounting

Institute	Reykjavik University-Department of Computer Science
Project accountant	Anna Lára Gísladóttir
Email	annal@ru.is

2.1 Doctoral student

Id Number	1005945369
Name	Émile Nadeau

2.1 Doctoral student

Initials	E.N.
Email	emile19@ru.is
Gender	Male
Institute	Reykjavik University-Department of Computer Science
Research Manager	Rannsóknarþjónusta HR
Research Manager Email	rannsoknir@ru.is

2.2 Supervisor(s)

Supervisor

Id Number	2111815679
Name	Henning Arnór Úlfarsson
Initials	H.A.Ú
Email	henningu@ru.is
Gender	Male
Institute	Reykjavik University-Department of Computer Science
Research Manager	Rannsóknarþjónusta HR
Research Manager Email	rannsoknir@ru.is

3.1 Duration

Years	2

3.2 Work Packages (WP)

Work Package

Name of WP	Develop algorithm to finds combinatorial systems automatically
Participant accountable for WP	
Start month of WP	1
End month of WP	12
Name of Milestone One	Find combintorial systems with a single variable
Month of First Milestone	4
Name of Milestone Two	Find combinatorial systems with multiple variables
Month of Second Milestone	8
Name of Milestone Three	Use combinatorial systems to enumerate permutation classes

3.2 Work Packages (WP)

Month of Third Milestone 12

Description

The PhD student will develop the theory on combinatorial systems and build algorithms to find automatically combinatorial systems in a universe of rules generated by combinatorial exploration. The proposer will also build algorithms that use the combinatorial systems to enumerate and generate permutations classes.

Deliverables and contributing staff

The PhD student will work with Henning Ulfarsson and Jay Pantone to develop the theory of combinatorial systems. He will integrate the new algorithms in the Combex beta and the PermScope algorithm. He will also write a paper about the theory of combinatorial systems.

Work Package

Name of WP Implement iterative deepening search in the framework.

Participant accountable for WP

Start month of WP 13

End month of WP 18

Name of Milestone One Obtain specification that were out of reach earlier

Month of First Milestone 15

Name of Milestone Two Obtain some theoretical results on the complexity of this approach

Month of Second Milestone 18

Description

The PhD student will implement iterative and deepening in the framework and use it with the PermScope algorithm to find specification that were out of reach earlier.

Deliverables and contributing staff

Iterative deepening search will be integrated to the Combex framework to expand the search space in a smarter way. The proposer will be supervised by Henning Ulfarsson.

Work Package

Name of WP Extend the PermScope algorithm to find specifications and combinatorial systems that describe permutation statistics in classes.

Participant accountable for WP

Start month of WP 19

End month of WP 24

Name of Milestone One Find specifications for permutation classes while tracking the inversion statistic

Month of First Milestone 21

Name of Milestone Two Extand the inversion tracking to more statistics

Month of Second Milestone 24

Description

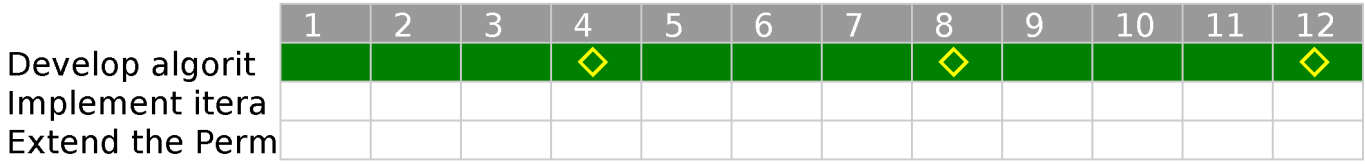
3.2 Work Packages (WP)

The proposer will extend the PermScope algorithm to track statistics. He will start by tracking inversions and then extend it to more statistics such as descents, major index and peaks.

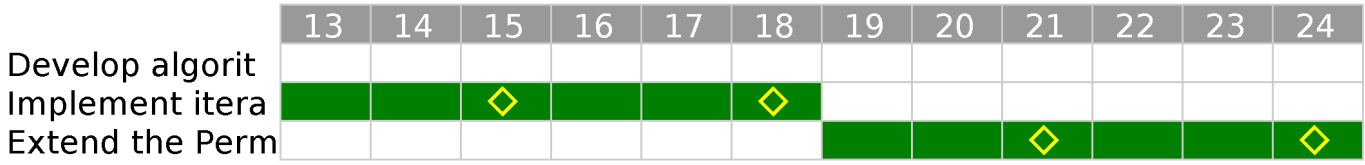
Deliverables and contributing staff

Supervised by Henning Ulfarsson, the proposer will integrate statistics tracking in the PermScope algorithm.

Year 1



Year 2



3.3 Activity by region

Reykjavík capital area	100 %
Reykjanes peninsula	0 %
W-Iceland	0 %
West fjords	0 %
NV-Iceland	0 %
NE-Iceland	0 %
E-Iceland	0 %
S-Iceland	0 %
Abroad	0 %
Total	100

4 Budget - Summary

4.1 Budget Year 1

Total expences

Man-months & salaries (in thousands of ISK)

Participant	Institute	Number of man-months	Salaries per month*	Total
E.N.	RU-DCS	12.0	445.0	5340

Travel expenses (in thousands of ISK)

Institute	Total expences	Explanation
RU-DCS	300	Research visits and pariticipation to international conferences

Contracted services (in thousands of ISK)

Institute	Total expences	Explanation
RU-DCS	0	

Publication expenses (in thousands of ISK)

Institute	Total expences	Explanation
RU-DCS	0	

Purchase of Equipment

Institute	Total expences	Explanation
RU-DCS	0	

Other Financing

Participant	Matching funds	Explanation	Amount
RU-DCS	Salaries		40
RU-DCS	Travel expenses		300

Total expences

Institute	RU-DCS								**Total**
Salaries	5340	0	0	0	0	0	0	0	5340
Travel expenses	300	0	0	0	0	0	0	0	300
Total	**5640**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	5640

Own Contribution

Institute	RU-DCS								Total
Salaries	40	0	0	0	0	0	0	0	40
Travel expenses	300	0	0	0	0	0	0	0	300
Total	340	0	0	0	0	0	0	0	340

Applied to IRF

Institute	RU-DCS								Total
Applied	5300	0	0	0	0	0	0	0	5300
Applied %	94	0	0	0	0	0	0	0	94
Overhead	1325	0	0	0	0	0	0	0	1325
Applied with overhead	6625	0	0	0	0	0	0	0	6625

4.2 Budget Year 2

Total expences

Man-months & salaries (in thousands of ISK)

Participant	Institute	Number of man-months	Salaries per month*	Total
E.N.	RU-DCS	12.0	445.0	5340

Operating expenses (in thousands of ISK)

Institute	Total expences	Explanation
RU-DCS	0	

Travel expenses (in thousands of ISK)

Institute	Total expences	Explanation
RU-DCS	300	Research visits and participation to international confenrences

Contracted services (in thousands of ISK)

Institute	Total expences	Explanation
RU-DCS	0	

Publication expenses (in thousands of ISK)

Institute	Total expences	Explanation
RU-DCS	0	

Purchase of Equipment

Institute	Total expences	Explanation
RU-DCS	0	

Other Financing

Participant	Matching funds	Explanation	Amount
RU-DCS	Salaries		40
RU-DCS	Travel expenses		300

Total expences

Institute	RU-DCS								**Total**
Salaries	5340	0	0	0	0	0	0	0	5340
Travel expenses	300	0	0	0	0	0	0	0	300
Total	**5640**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	5640

Own Contribution

Institute	RU-DCS								Total
Salaries	40	0	0	0	0	0	0	0	40
Travel expenses	300	0	0	0	0	0	0	0	300
Total	340	0	0	0	0	0	0	0	340

Applied to IRF

Institute	RU-DCS								Total
Applied	5300	0	0	0	0	0	0	0	5300
Applied %	94	0	0	0	0	0	0	0	94
Overhead	1325	0	0	0	0	0	0	0	1325
Applied with overhead	6625	0	0	0	0	0	0	0	6625

Summary All Years

Total expences

Institute	RU-DCS	**Total**

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THE ICELANDIC CENTRE FOR RESEARCH • Borgartún 30 • 105 Reykjavík • Tel. (354) 515 5800;

Total expences

Salaries	10680	0	0	0	0	0	0	0	10680
Travel expenses	600	0	0	0	0	0	0	0	600
Total	**11280**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	11280

Own Contribution

Institute	RU-DCS								Total
Salaries	80	0	0	0	0	0	0	0	80
Travel expenses	600	0	0	0	0	0	0	0	600
Total	680	0	0	0	0	0	0	0	680

Applied to IRF

Institute	RU-DCS								Total
Applied	10600	0	0	0	0	0	0	0	10600
Applied %	93	0	0	0	0	0	0	0	93
Overhead	2650	0	0	0	0	0	0	0	2650
Applied with overhead	13250	0	0	0	0	0	0	0	13250

5.1 Attachments

Project Description template	project_description.pdf
Project Description Reference list (Bibliography)	references.pdf
Cv PhD Student	cv_emile.pdf
Doctoral student admission statement	Confirmation of registration-PhD in Computer Science-2019-2.pdf
Cv Supervisor	CV-Henning.pdf