Formal Language Driven Data Analysis Research Group Report

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Saint Petersburg State University

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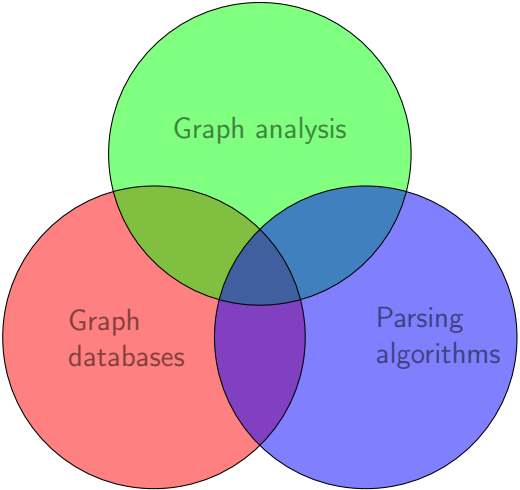
Research Area



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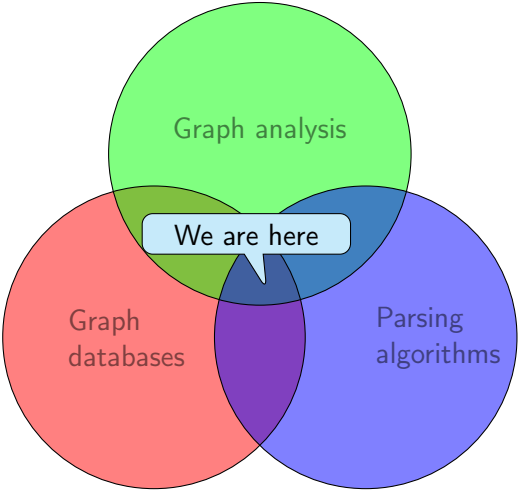
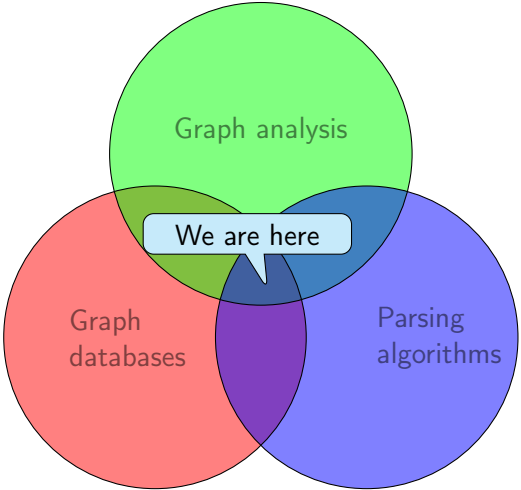


Research Area

Applications

- Code analysis
- Code querying
- Code parsing



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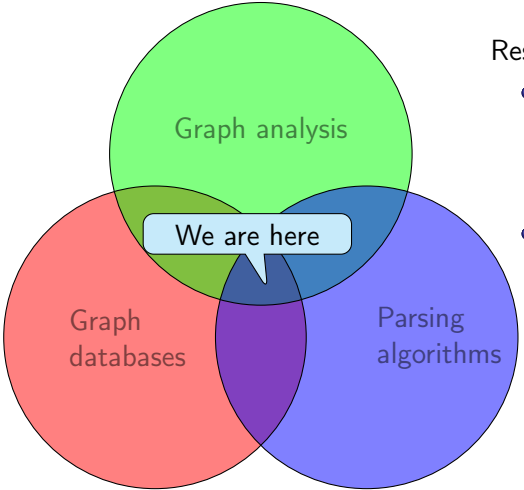

Research directions

- Graph algorithms
  - Dynamic graphs
  - Linear algebra
  - Path querying
- Formal languages
  - Languages classes and properties
  - Parsing algorithms
  - Formal language constrained path querying

Code Analysis and Querying

Huge software projects

- Millions LOC
- Complex structure
- Dynamic (IDE-level analysis)

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Graph storage

- Graph representation
- Query languages
- Query evaluation engines

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Graph analysis algorithms

- Performance
- Nontrivial techniques (esp. for dynamic graphs)

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Linear algebra (GraphBLAS)

- Parallel (multicore CPU, GPGPU)
- Flexible, expressive

Code parsing (for IDE)

Parsing for IDE

- Frequent code updates
- Partially correct code
- Multiple languages support
- Performance-critical

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Parsing technique

- Error recovery
- Reparsing
- Performance
- Flexibility

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Language description

- Modern syntax support (ambiguity, formatting-sensitivity)
- Human-friendly

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Advanced parsing algorithms

- New formal classes of languages
- Error recovery
- Incrementalization
- Performance

Results

Graph analysis for symbolic execution engine

Research prototype

- Graph extraction and update mechanism
- Constrained shortest paths for dynamic graph

Results

Graph analysis for symbolic execution engine	Research prototype	• Graph extraction and update mechanism • Constrained shortest paths for dynamic graph
Graph querying algorithms	Research prototype	• New algorithms • Complexity analysis • Performance analysis

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Graph querying algorithms	Research prototype	• New algorithms • Complexity analysis • Performance analysis
Sparse linear algebra library on GPGPU	Research prototype	• Operations implementation • Optimizations • Performance analysis

Rustam Azimov (Graph analysis and querying)

- ✔ Linear algebra based graph analysis algorithms research and development
  - Regular path querying
  - Context-free path querying
  - Multiple context-free path querying
- ✔ Graph analysis algorithms evaluation
  - Formal language constrained path querying
  - Static code analysis cases
  - Linear algebra based algorithms
- ⚙ PhD defense

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- ⌛ Code analysis specific dataset for graph analysis algorithms evaluation and comparison
  - New graphs
  - New scenarios
  - New quey types
- ⌛ Graph analysis algorithms evaluation and comparison
  - New cases
  - New graphs
  - New algorithms

Ekaterina Shemetova (Graph analysis and querying)

- ✔ Linear algebra based graph analysis algorithms research and development
  - Complexity analysis
  - Specific cases of graphs and language classes
- ✔ Graph analysis algorithms evaluation
  - Formal language constrained path querying
  - Static code analysis cases
  - GLL-based algorithms
- ⚙ Dynamic graph analysis

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- ⌛ Dynamic graph analysis
  - Specific algorithms for symbolic execution engine and code analysis
  - Theoretical analysis
  - Performance analysis
- ⌛ Parsing algorithms development end evaluation
  - Dynamic reparsing
  - Error recovery

Vladimir Kutuev (Graph analysis and querying)

- ✔ Graph analysis algorithms development and evaluation
  - Linear algebra based algorithm
  - Static code analysis cases
- ✔ Graph querying algorithm fo Neo4j development and evaluation
  - Static code analysis cases
  - GLL-based algorithms

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- **Collaboration will be paused**

Denis Porsev (Graph analysis and querying)

- ✔ New linear algebra based algorithm for multiple source regular path querying
  - Development
  - Implementation
  - Evaluation

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- ✔ New linear algebra based algorithm for multiple source regular path querying
  - Development
  - Implementation
  - Evaluation
- ⌛ The algorithm improvements
  - Performance analysis and improvements
  - Evaluation and comparison
  - Flexibility improvements

Vlada Pogozhelskaya (Graph analysis and querying)

- ✔ Neo4j-based graph analysis algorithm evaluation
  - General cases
  - Static code analysis cases

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Ilya Epelbaum (Graph analysis and querying)

- ✔ Multiple Context-Free Language constrained path querying algorithm in terms of linear algebra
  - Development
  - Implementation
  - Evaluation

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- **Collaboration stopped**

Egor Orachyov (Linear algebra for GPGU)

- ✔ GPGPU-based sparse linear algebra library design and implementation
  - High-level design and architecture of portable extensible library
  - Project infrastructure
  - High-level concepts implementation

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  - High-level design and architecture of portable extensible library
  - Project infrastructure
  - High-level concepts implementation
- ⌛ Basic low-level primitives implementation
  - Data structures
  - Operations
- ⌛ Basic graph algorithms implementation and evaluation
  - BFS
  - TC
- ⌛ Out-of-GPGPU-memory graphs handling

Dmitriy Panfilenok (Linear algebra for GPGU)

- ✔ Kernel fusion optimization for element-wise matrix-matrix operations
  - Development
  - Implementation
  - Evaluation

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Kirill Garbar (Linear algebra for GPGU)

- ✔ Well-typed element-wise matrix-matrix operations: generic generalized kernels for GPPGU
  - Development
  - Implementation
  - Evaluation

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- ✔ Well-typed element-wise matrix-matrix operations: generic generalized kernels for GPPGU
  - Development
  - Implementation
  - Evaluation
- ⌛ Applied linear algebra based graph analysis algorithms implementation and evaluation
  - BFS
  - TC
  - Supplementary matrix-vector operations

Artem Chernikov (Linear algebra for GPGU)

- ✔ GPGPU-based operations on vectors and matrices
  - Collections sort
  - Matrix transpose

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- ✔ GPGPU-based operations on vectors and matrices
  - Collections sort
  - Matrix transpose
- ⌛ Generic well-typed matrix-matrix multiplication
  - Sparse matrices
  - Evaluation and comparison

Alexandra Istomina (Graph analysis and querying)

- Collaboration research in previous academic year but was paused for summer
- Research topic: graph analysis algorithms for special types of graphs and languages

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- Graph analysis algorithms for special types of graphs and languages
  - Code analysis specific cases

The Plan

Code querying for declarative code analysis

- Code querying and graph querying languages
  - CodeQL
  - Datalog
  - GQL
  - ...
- Query evaluation engines
  - Performance
  - Flexibility
- Graph analysis algorithms
  - Performance
  - Scalability
  - Incrementalization

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Parsing techniques and algorithms

- Language specification formalisms
- Error recovery techniques
- Reparsing techniques

Scholarships request (2022–2023 academic year)

Student	Amount (per month)	Total (9 month: September – May)
Egor Orachyov	40 000	360 000
Alexandra Istomina	40 000	360 000
Kirill Garbar	30 000	270 000
Denis Porsev	30 000	270 000
Total:	140 000	1 260 000