OSCAR: Integrating GAP and Julia

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University of Siegen

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Outline

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People

All of this is joint work with

- William Hart (TU Kaiserslautern)
- Thomas Breuer (RWTH Aachen)
- Reimer Behrends (TU Kaiserslautern)
- Max Horn (JLU Gießen)
- Markus Pfeiffer (University of St Andrews)
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For a complete list of people involved in the various parts of OSCAR, see https://oscar.computeralgebra.de/credits.

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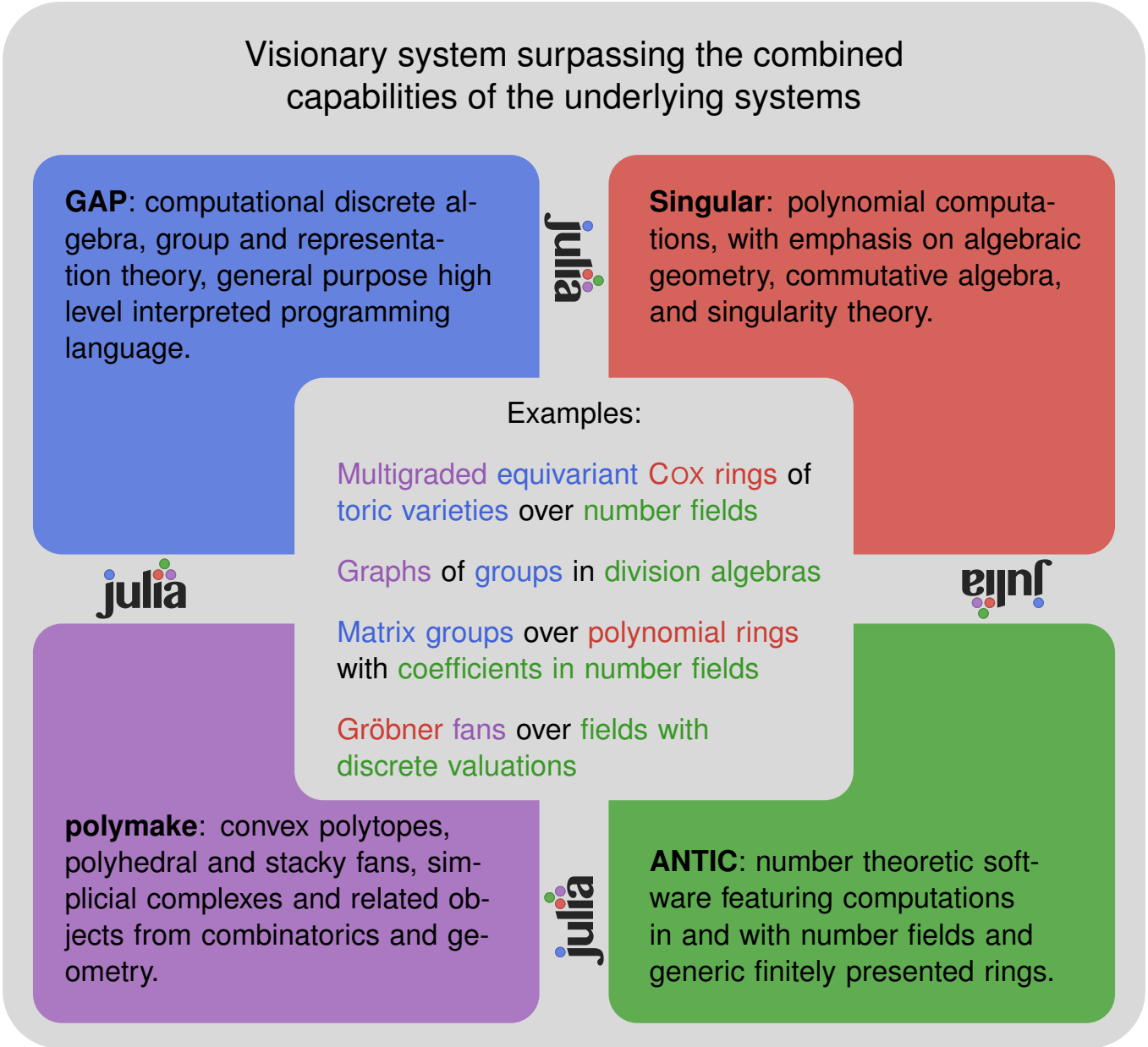
Overview


Visionary system surpassing the combined capabilities of the underlying systems
GAP: computational discrete algebra, group and representation theory, general purpose high level interpreted programming language.
Singular: polynomial computations, with emphasis on algebraic geometry, commutative algebra, and singularity theory.
Examples:
Multigraded equivariant Cox rings of toric varieties over number fields
Graphs of groups in division algebras
Matrix groups over polynomial rings with coefficients in number fields
Gröbner fans over fields with discrete valuations
polymake: convex polytopes, polyhedral and stacky fans, simplicial complexes and related objects from combinatorics and geometry.
ANTIC: number theoretic software featuring computations in and with number fields and generic finitely presented rings.
julia
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Create a new CAS integrating GAP, Singular, polymake, and ANTIC as tight as possible.

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- removing the barriers between systems by unifying low-level data structures;
- make all functionality from each system available in every other system;
- make all systems share a common mid-level programming layer.

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- GAP: Second part of talk

Example: Using Singular with Nemo rings

Example for using Nemo number fields as coefficient rings in Singular

`Julia_rings_with_Singular.ipynb`

Resources

All information about the OSCAR project can be found on

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On the page you can find

- news,
- blog posts,
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- and installation instructions.

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https://github.com/oscar-system

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- Nested lists of the above to Arrays or Tuples

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- If necessary and possible, input data is converted to Julia
- Calling only possible for convertible types and Julia objects

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```
function orbit( element, generators, action )
  work_set = [ element ]
  return_set = [ element ]
  generator_length = gap_LengthPlist(generators)
  while length(work_set) != 0
    current_element = pop!(work_set)
    for current_generator_number = 1:generator_length
      current_generator = gap_ListElement(generators,
                                          current_generator_number)
      current_result = gap_CallFunc2Args(action,current_element,
                                         current_generator)
      is_in_set = false
      for  i in return_set
        if i == current_result
          is_in_set = true
          break
        end
      end
      if ! is_in_set
        push!( work_set, current_result )
        push!( return_set, current_result )
      end
    end
  end
  return return_set
end
```

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5769
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gap> orbit_c( 1, S, OnPoints );; time;
46
```

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julia> LibGAP.from_gap( size_gap, Int64 )
6
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From the GAP side

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- Flexible type system: Objects can learn about themselves
- Built-in traits: Known properties of objects decide which variant of an algorithm to use
- Immediate propagation: Second execution layer is used to spread properties between objects
- Categorical programming language as defined in the CAP project

Example: Using Singular in GAP via Julia

Example for using Singular in GAP via Julia

`Using Singular from GAP.ipynb`

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- it adds a layer of indirections and causes inefficiencies and
- unreachable cycles that involve both GAP and Julia objects cannot be reclaimed, so it leads to memory leaks.

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- Thus using Julia objects from GAP and GAP objects from Julia works without any GC overhead (essentially no penalty at all)

Acknowledgements

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SYMBOLIC TOOLS

OPEN
DREAMKIT