First Committee Meeting

Progress Report

Jason Balaci

McMaster University

Oct. 21st, 2021

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2. Project
    - Drasil
    - Goal #1: Typed Expression Language
    - Goal #2: Model Discrimination – “ModelKinds”
3. References

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Me, Camping in Killarney Prov. Park, Fall 2019

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- Graduate of *McMaster University*, holding...
  - Hons. Actuarial and Financial Mathematics (B.Sc.)
  - Minor in Computer Science
- Currently pursuing a thesis-based Master's of Computer Science (M.Sc) at *McMaster University*, under the supervision of **Dr. Jacques Carette**.

Me, Camping in Killarney Prov. Park, Fall 2019

Overview of Progression Towards C.S. M.Sc.

Course-related progression

- I'm required to complete[1][2]:

[1] https://academiccalendars.romcmaster.ca/preview_program.php?catoid=45&poid=23470&returnto=9166

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- Together, the courses completed satisfies the "Courses Requirement" as mentioned in the academic calendar[1] and the "Regulations for the Computer Science M.Sc. Program" document[2].

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- Supervisory committee is formed, and we are currently having our first supervisory committee meeting.
    - *Supervisor*: Dr. Jacques Carette
    - Dr. Spencer Smith
    - Dr. Wolfram Kahl

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Drasil...

Drasil's Logo
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- has a website[1]!

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Drasil

“Generate All The Things!”

- TODO: here!

Drasil Case Studies

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Drasil Case Studies

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    - **Slope Stability Analysis Program (SSP)** - Assessment of the safety of a slope (composed of rock and soil) subject to gravity, identifying the surface most likely to experience slip and an index of its relative stability (factor of safety).

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The Drasil website is also generated by Drasil!

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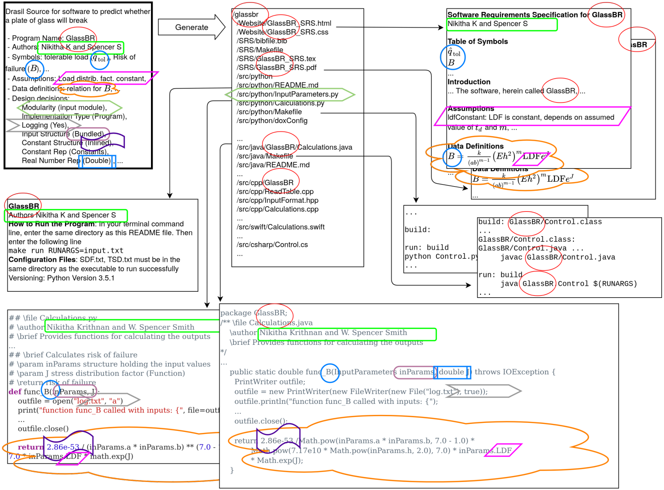
Taking a closer look at one of the examples: GlassBR

GlassBR Generates Code!



Drasil Source for software to predict whether a plate of glass will break

- Program Name: GlassBR
- Authors: Nikitha K and Spencer S
- Symbols: tolerable load ($\hat{q}_{\text{tol}}$), Risk of failure (B), ...
- Assumptions: Load distrib. fact. constant,
- Data definitions: relation for B, ...
- Design decisions:
  Modularity (input module),
  Implementation Type (Program),
  Logging (Yes),
  Input Structure (Bundled),
  Constant Structure (Inlined),
  Constant Rep (Constants),
  Real Number Rep (Double), ...

```
/glassbr
 /Website/GlassBR_SRS.html
 /Website/GlassBR_SRS.css
 /SRS/bibfile.bib
 /SRS/Makefile
 /SRS/GlassBR_SRS.tex
 /SRS/GlassBR_SRS.pdf
 /src/python
 /src/python/README.md
 /src/python/InputParameters.py
 /src/python/Calculations.py
 /src/python/Makefile
 /src/python/doxConfig

 ...
 /src/java/GlassBR/Calculations.java
 /src/java/Makefile
 /src/java/README.md
 ...
 /src/cpp/GlassBR
 /src/cpp/ReadTable.cpp
 /src/cpp/InputFormat.hpp
 /src/cpp/Calculations.cpp
 ...
 /src/swift/Calculations.swift
 ...
 /src/csharp/Control.cs
 ...
```

Software Requirements Specification for GlassBR

Nikitha K and Spencer S

Table of Symbols

$\hat{q}_{\text{tol}}$

B

...

Introduction

... The software, herein called GlassBR, ...

Assumptions

ldfConstant: LDF is constant, depends on assumed value of t_d and m, ...

Data Definitions

$B = \frac{k}{(ab)^{m-1}}\left(Eh^2\right)^m \text{LDF} e^J$

...

sBR

Data Definitions

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...

GlassBR

Authors Nikitha K and Spencer S

How to Run the Program: In your terminal command line, enter the same directory as this README file. Then enter the following line

`make run RUNARGS=input.txt`

Configuration Files: SDF.txt, TSD.txt must be in the same directory as the executable to run successfully

Versioning: Python Version 3.5.1

```
...

build:

run: build
python Control.py
...
```

```
build: GlassBR/Control.class
...
GlassBR/Control.class:
GlassBR/Control.java ...
    javac GlassBR/Control.java

run: build
    java GlassBR.Control $(RUNARGS)
...
```

```
## \file Calculations.py
# \author Nikitha Krithnan and W. Spencer Smith
# \brief Provides functions for calculating the outputs
...
## \brief Calculates risk of failure
# \param inParams structure holding the input values
# \param J stress distribution factor (Function)
# \return risk of failure
def func_B(inParams, J):
    outfile = open("log.txt", "a")
    print("function func_B called with inputs: {", file=outf
    ...
    outfile.close()

    return 2.86e-53 / (inParams.a * inParams.b) ** (7.0 -
7.0 * inParams.LDF * math.exp(J)
```

```
package GlassBR;
/** \file Calculations.java
  \author Nikitha Krithnan and W. Spencer Smith
  \brief Provides functions for calculating the outputs
*/
...
  public static double func_B(InputParameters inParams, double J) throws IOException {
    PrintWriter outfile;
    outfile = new PrintWriter(new FileWriter(new File("log.txt", true));
    outfile.println("function func_B called with inputs: {");
    ...
    outfile.close();

    return 2.86e-53 / Math.pow(inParams.a * inParams.b, 7.0 - 1.0) *
          Math.pow(7.17e10 * Math.pow(inParams.h, 2.0), 7.0) * inParams.LDF
          * Math.exp(J);
  }
```

Knowledge flow from “knowledge-base”/source to artifacts, by Dr. Spencer Smith

Which case studies currently generate code?

- **GlassBR** - Predicting whether or not a glass slab is likely to resist a specified blast.

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Why don't all case studies generate software artifacts?

Where will I be contributing?

[1] Terminology is currently being changed, but is not reflected in many documents yet.

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A few, notable, blocking problems:

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- Confidently generating usable software artifacts without strong type information places significant stress on developers, resulting in a higher likelihood of bugs in artifacts.

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A few, notable, blocking problems:

- Confidently generating usable software artifacts without strong type information places significant stress on developers, resulting in a higher likelihood of bugs in artifacts.
- Existing "theories"/"*Models"[1] don't expose enough information. They must be enriched, so that we can pull more information from them in straightforward manner.

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Goal #1: Typed Expression Language

The Problem

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- Ensure only admissible expressions are used in GOOL-supported languages, and that all expressions are coherent.

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- Ensure only admissible expressions are used in GOOL-supported languages, and that all expressions are coherent.
- Eases developer cognitive load when writing expressions, as they will need to ensure their expressions are coherent, or else a type error will be thrown.

Goal #1: Typed Expression Language

What makes up a “good” solution?

Goal #1: Typed Expression Language

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- Catches, within reason, all possible scenarios where an expression goes awry.
- Allows GOOL code generator to also become typed!

Goal #1: Typed Expression Language

Current Progression

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    - Theories that rely on discussion of terms only found ‘ModelExpr’ may only have code generation made possible if we have rich enough data (see goal #2)
  - ‘CodeExpr’ contains a total conversion from ‘Expr’ with a few extra functionalities for GOOL
  - Created a “typed tagless final” smart constructor encoding for writing expressions in “Expr” (or, optionally, ModelExpr).

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What are the next steps?

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- Continuing to remove terms.
- Moving literals from “Expr” & “ModelExpr” into their own small language, so that areas that want *strictly* literals can also have stronger restrictions on allowed data (terms).

Goal #2: Model Discrimination – “ModelKinds”

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Goal #2: Model Discrimination – “ModelKinds”

The Problem

- “RelationConcept”s don’t contain enough information on their own to be a core component usable in code generation.
- They were essentially “Relation”s (“Expr”s) with a natural language description of them.
- If the “shape” of the expressions are not uniform, then writing more “interpreters”/“views”/code generators for them required difficult pattern analysis. It’s also not a total-conversion.

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Goal #2: Model Discrimination – “ModelKinds”

What makes up a “good” solution?

- A good solution involves making the “Relation”s a “view” of a more data-rich specialized container for each kind of “*Model”.
- “ModelKinds”
- By constructing our final data views through “more steps” (e.g., with more depth), we create a system of specialization, and we can start to see how specialization will occur.

Goal #2: Model Discrimination – "ModelKinds"

Current Progression

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Current Progression

- Considerable number of “theories”/“*Models” have been restructured, but there are still many that are pending typing. Most are best to be done once we have a typed expression language, and the rest are differential equation-related models (primarily Dong’s domain).

Goal #2: Model Discrimination – “ModelKinds”

What are the next steps?

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What are the next steps?

- Understanding what kinds of needs we have for “collections”, pushing this information back into the typed expression language (once that is fully typed), and then further creating model containers for these models.

Goal #2: Model Discrimination – “ModelKinds”

What are the next steps?

- Understanding what kinds of needs we have for “collections”, pushing this information back into the typed expression language (once that is fully typed), and then further creating model containers for these models.
- For the differential equation-related models, we will need to build appropriate models for each kind.

Acknowledgements

Fin.

Thank you!

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References I

- Carette, J., Smith, S., Balaci, J., Hunt, A., Wu, T.-Y., Crawford, S., Chen, D., Szymczak, D., MacLachlan, B., Scime, D., and Niazi, M. (2021).
  Drasil.

- Yggdrasil - Wikipedia (2021).
  Yggdrasil.