

First Committee Meeting

Progress Report

Samuel Crawford

McMaster University

June 19, 2023

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- Drasil
- The Common Drasil Workflow
- Why Test Generated Code?
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About Me

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- Graduated from McMaster University (2022)
 - Bachelor of Engineering (B.Eng.) in Software Engineering
 - Worked on Drasil as an Undergraduate Summer Research Assistant (during the summers of 2018 and 2019)



About Me

- I am **Samuel "Sam" Crawford**
- Graduated from McMaster University (2022)
 - Bachelor of Engineering (B.Eng.) in Software Engineering
 - Worked on Drasil as an Undergraduate Summer Research Assistant (during the summers of 2018 and 2019)
- Currently pursuing a Master of Applied Science (M.A.Sc.) in Software Engineering under the supervision of **Dr. Jacques Carette** and **Dr. Spencer Smith**



Overview of Progression Towards M.A.Sc.

Course-related progression

- I'm required to complete:
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 - One "Theory" course
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 - CAS 781: Advanced Topics in Computing and Software
(High-Performance Scientific Computing) - Winter 2023

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Thesis/research-related Progression

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- Pivoted to "full-time research" for Spring 2023 (and beyond)
- Formed my supervisory committee; we are currently having our first supervisory committee meeting!

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Preface

What is Drasil?

Drasil is "a framework for generating all of the software artifacts from a stable knowledge base, focusing currently on scientific software"

[Hunt et al., 2021]



Drasil's Logo [Carette et al., 2021]

¹<https://jacquescarette.github.io/Drasil/>

Preface

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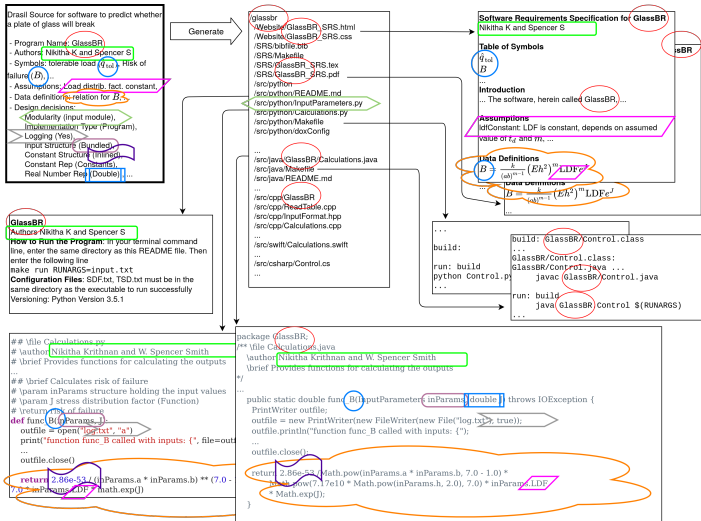
- This knowledge, using recipes, is used to generate software artifacts, including:
 - SRS (HTML, PDF, Jupyter)
 - Code (Python, Java, C#, C++, Swift)
 - READMEs
 - Makefiles
 - Its own website¹!



Drasil's Logo [Carette et al., 2021]

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Visualizing Drasil's Traceability



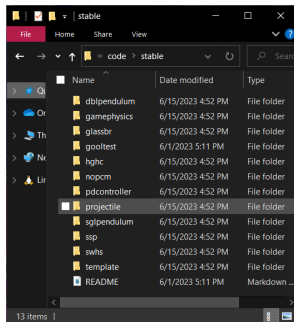
Knowledge flow from knowledge base to artifacts; by Dr. Spencer Smith

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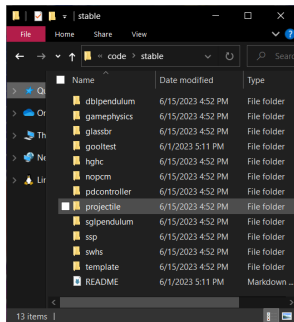
Contents of stable

```
diff --strip-trailing-cr -r -X ../.gitignore
    stable/projectile/SRS/HTML/Projectile_SRS.html
build/projectile/SRS/HTML/Projectile_SRS.html
5c5,7
< <title>Software Requirements Specification for
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An example log

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An example log

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- Why use test cases for verification as opposed to, say, consistency/correctness checks?
 - 1 A more well-defined, Master's level scope
 - 2 Targets a more complex artifact that is harder to verify
 - 3 Gives Drasil another "bragging point"!

The Common Drasil Workflow

Example: Projectile

The Common Drasil Workflow

Example: Projectile

- 1 Create a manual version of an artifact

Sketch of SRS for Projectile

① Theoretical Models

Acceleration $\vec{a} = \frac{d\vec{v}}{dt}$ (acceleration) (velocity) (\vec{a} and \vec{v} are general ~~use~~, abstract vectors. We have not yet stated a basis for them.)

Velocity $\vec{v} = \frac{d\vec{u}}{dt}$ (position) (\vec{v} and \vec{u} are general, abstract vectors. We have not yet stated a basis for them.)

② Assumptions (these are relationships b/w assumptions, but we cannot currently capture them.)

- A1 - 2D
- A2 - Cartesian coordinate system
- A3 - the origin is located coincident with the launcher
- A4 - up is positive (we'll label this direction y)
- A5 - to the right is positive (we'll label this direction x)
- " " " " is constant

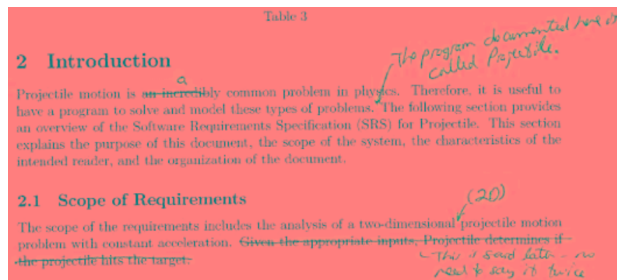
this should be part of the terminology (so should target)

Sketch of Projectile SRS [Smith, 2019]

The Common Drasil Workflow

Example: Projectile

- 1 Create a manual version of an artifact
- 2 Understand it (and its components) well



Review of Manual Projectile SRS [Smith and Crawford, 2019]

The Common Drasil Workflow

Example: Projectile

- 1 Create a manual version of an artifact
- 2 Understand it (and its components) well
- 3 Generate it!

Introduction

Projectile motion is a common problem in physics. Therefore, it is useful to have a program to solve and model these types of problems. The program documented here is called Projectile.

The following section provides an overview of the Software Requirements Specification (SRS) for Projectile. This section explains the purpose of this document, the scope of the requirements, the characteristics of the intended reader, and the organization of the document.

Scope of Requirements

The scope of the requirements includes the analysis of a two-dimensional (2D) projectile motion problem with constant acceleration.

HTML Version of Generated Projectile SRS [Crawford et al., 2023]

The Common Drasil Workflow

Applied to Testing

1. Create a manual version of an artifact

- Manual unit tests (26 **pass**, 18 **fail with known reason**)

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Applied to Testing

1. Create a manual version of an artifact

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```
## \brief Tests reading valid input
@mark.parametrize("filename, v_launch, theta, p_target",
                  get_expected("v_launch", "theta", "p_target"))
def test_get_input_valid(filename, v_launch, theta, p_target):
    assert isclose(conftest.inParams[filename].v_launch, v_launch)
    assert isclose(conftest.inParams[filename].theta, theta)
    assert isclose(conftest.inParams[filename].p_target, p_target)
```

Sample from InputParameters_test.py

The Common Drasil Workflow

Applied to Testing

1. Create a manual version of an artifact

- Manual unit tests (26 **pass**, 18 **fail with known reason**)

```
def build_mocks(*attrs):
    mocks = []
    defaults = ["v_launch", "theta", "p_target"]
    for d in get_expected(*(defaults + list(attrs))):
        mock_attrs = dict()
        for i, attr in enumerate(defaults + list(attrs), start=1):
            mock_attrs[attr] = d[i]
        mock = Mock()
        mock.configure_mock(**mock_attrs)
        mocks.append(mock)
    return mocks

## \brief Tests calculation of t_flight with valid input
@mark.parametrize("mock", build_mocks("t_flight"))
def test_func_t_flight_valid(mock):
    assert isclose(Calculations.func_t_flight(mock, valid_g), mock.t_flight)
```

Sample from Calculations_test.py

The Common Drasil Workflow

Applied to Testing

1. Create a manual version of an artifact

- Manual unit tests (26 **pass**, 18 **fail with known reason**)

```
## \brief Tests writing valid input
@mark.parametrize("s, d_offset, t_flight", get_expected("d_offset", "t_flight"))
def test_get_input_valid(s, d_offset, t_flight):
    OutputFormat.write_output(s, d_offset, t_flight)
    with open("output.txt") as f:
        assert f.readlines() == [f"s = {s}\n",
                                  f"d_offset = {d_offset}\n",
                                  f"t_flight = {t_flight}\n",]
```

Sample from OutputFormat_test.py

The Common Drasil Workflow

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1. Create a manual version of an artifact

- Manual unit tests (26 **pass**, 18 **fail with known reason**)
- Manual system tests (3 **pass**, 4 **fail with known reason**)

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- Manual system tests (3 **pass**, 4 **fail with known reason**)

```
## \brief Tests main with valid input file
@mark.parametrize("filename", get_expected())
def test_main_valid(monkeypatch, filename):
    with monkeypatch.context() as m:
        m.setattr(sys, 'argv', ['Control.py', str(Path("test/test_input") /
            f"{filename}.txt")])
        Control.main()
    assert read_file(output_filename) == read_file(str(Path("test/test_output") /
        f"{filename}.txt"))
```

Sample from Control_test.py

The Common Drasil Workflow

Applied to Testing

2. Understand the manual artifact (and its components) well

The Common Drasil Workflow

Applied to Testing

2. Understand the manual artifact (and its components) well

- Changes made to "stable" to facilitate testing
 - The inclusion of `__init__.py` files to improve import statements
 - Wrapping `Control.py`'s functionality in a `main` function
 - Changing how command line parameters are passed to `Control.py`

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Applied to Testing

2. Understand the manual artifact (and its components) well

- Changes made to "stable" to facilitate testing
 - The inclusion of `__init__.py` files to improve import statements
 - Wrapping `Control.py`'s functionality in a `main` function
 - Changing how command line parameters are passed to `Control.py`
- Changes to be made to generated code to improve correctness
 - Invalid values should stop the calculations [Crawford et al., 2023]
 - Assumptions, such as values of constants, should be verified

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If the code is being generated from a stable knowledge base, then it should be correct. Why waste effort testing it?

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- 2 There are plenty of places for a mistake to be introduced
- 3 Testing provides a greater degree of confidence in Drasil's capabilities
- 4 Generating code for testing allows for it to be done "properly" instead of taking shortcuts commonly taken by humans

Next Steps

2. Understand the manual artifact (and its components) well

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"The information you have should be just as useful for generating tests as it should be for manually running them." — Dr. Jacques Carette

Next Steps

3. Generate it!

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- Test cases will then be written for:
 - Other variabilities of Projectile's Python implementation
 - Projectile's implementation in other languages
 - Other examples where code is generated: GlassBR, NoPCM, DbIPendulum, PD Controller [Hunt et al., 2021]

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 - Other variabilities of Projectile's Python implementation
 - Projectile's implementation in other languages
 - Other examples where code is generated: GlassBR, NoPCM, DbIPendulum, PD Controller [Hunt et al., 2021]
- These test cases will also be added to Drasil's CI/CD to ensure that future changes preserve the code's functionality

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- The past and current Drasil team have created a truly amazing framework!

Thank you!
Questions?

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