TIME-TRAVELING QUERIES
FOR FASTER DEBUGGING
AND PROGRAM COMPREHENSION

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Context: The debugging process

Debugging is a time-consuming iterative process:

- Formulate a hypothesis
- Test the hypothesis
- Repeat
- Fixed?
- Yes
- Done

What is the cause of the error?

To understand the behavior of a program, developers ask program comprehension questions:
- When during the execution is this method called?
- Where are instances of this class created?
- Where is this variable or data being accessed?
- Etc.

Problem: Understanding programs for debugging is difficult

To find answers, developers explore their program executions using debugging tools

Debugging question: What is the value of this variable during the execution?

Find answers directly in your query result (Don’t miss target!).

"Click & Time-Travel" Reverse or advance the execution jumping directly to any of the results timestamp (Less tedious!).

Explore your execution states forward or backward.

Do you have another debugging question? Just select another query!

There is no query for your debugging question? Write your own TTQ!

Example:

```
"list global variables assignments"
select [:state] state assignment and [:state node variable ts_GlobalVariable] ]
collect [:state] 
Result: new bytecodeIndex; state bytecodeIndex; 
variableName; state variableAssignmentName; 
yourself!
```

Solution: Time-Traveling Queries

**Time-Traveling Queries (TTQs)**

Do you have a debugging question?

Select a Time-Traveling Query from the Queries Menu!

- TTQs request information of an execution related to common debugging questions.
- Find answers directly in your query result (Don’t miss target!).
- "Click & Time-Travel" Reverse or advance the execution jumping directly to any of the results timestamp (Less tedious!).
- Explore your execution states forward or backward.

Do you have another debugging question? Just select another query!

There is no query for your debugging question? Write your own TTQ!

Example:

```
"list global variables assignments"
```

```
From where to extract the data?
```

```
What program states are relevant?
```

```
What should be included in the results?
```

**Time-Traveling Queries Evaluation**

With TTQs, developers perform program comprehension tasks more accurately, faster, and with less effort than with standard debugging tools.

**Controlled Experiment**

- Repeated Measures Design (Within-subject)
- 34 Participants.

**Research Question**

Do TTQs improve program comprehension tasks of participants regarding precision, time spent, and efforts? (vs. using standard debugging tools)

**Results**

- **30% More Precise**
- **28% Faster**
- **38% Less Actions**

**Control:** Without Time-Traveling Queries  
**TTQ:** Using Time-Traveling Queries


Future work

- Scaling the solution to daily debugging scenarios.
- Studying new relevant queries.
- Research TTQs generalization to different programming languages.
- Designing new TTQs-based debugging tools.

Code and video demonstration available at: github.com/Willembrinck/TTQ-Debugging