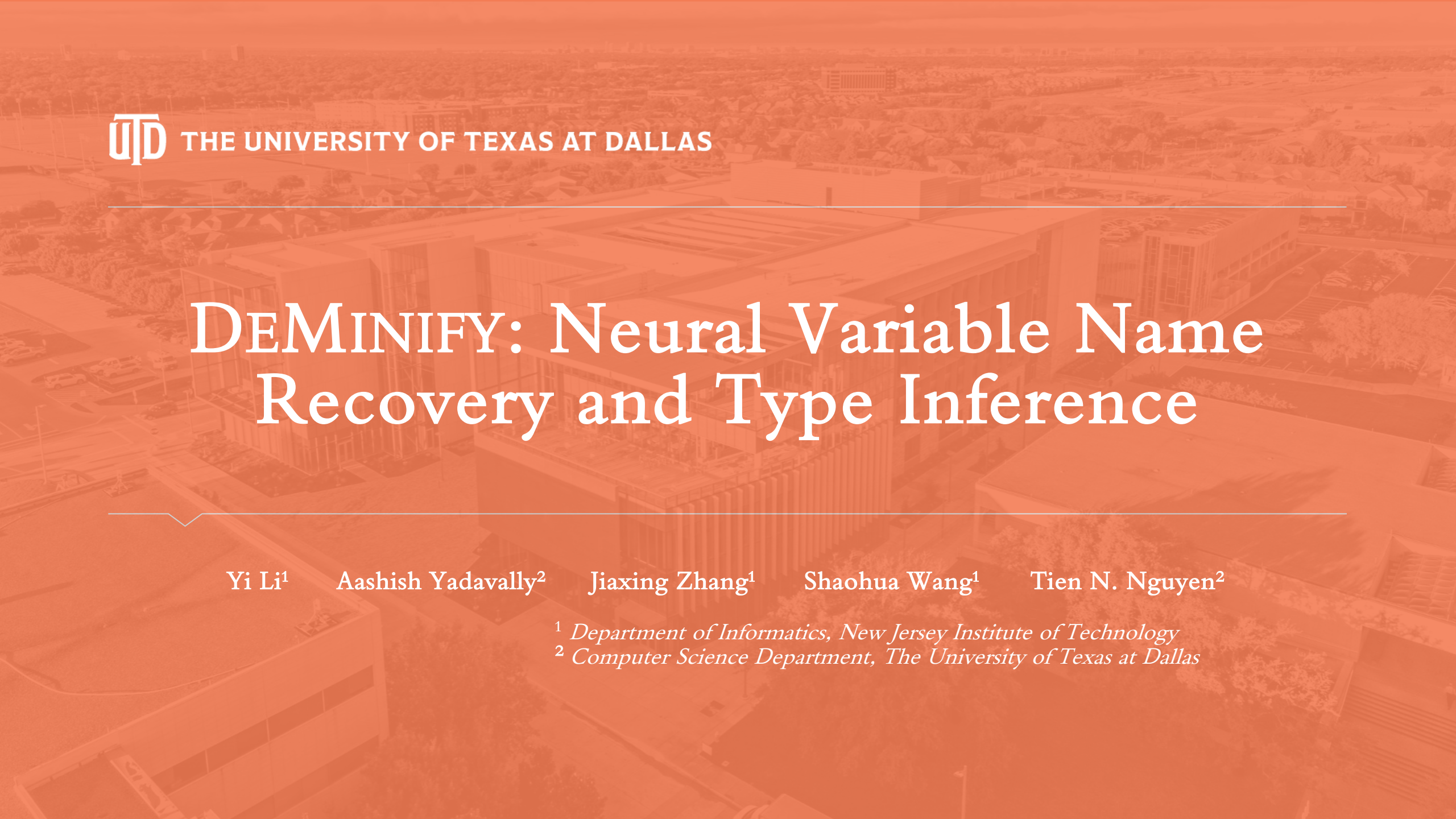

THE UNIVERSITY OF TEXAS AT DALLAS

DeMinify: Neural Variable Name Recovery and Type Inference

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[2] *Computer Science Department, The University of Texas at Dallas*

Background

- When the source code needs to be executed on the client side, it is often obfuscated, replacing the variable names with short, opaque, and meaningless names.

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def exportSelection(self, root, doc):
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    selection = doc.getSelection()
    if selection.rangeCount > 0:
        range_ = selection.getRangeAt(0)
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def exportSelection(self, w, b):
    if not w:
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Figure. An original code snippet from a project in GitHub (*left*), and its minified version (*right*).

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- The deminification of the same too, is highly relevant in reverse engineering, helping cybersecurity and software analysts identify potentially malicious code.

Motivating Example

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def exportSelection(self, root, doc):
    if not root:
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    selection = doc.getSelection()
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                              …
    trailingImageCount = self.getTrailingImageCount(
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    if start != 0:
        emptyBlocksIndex =
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                    doc, root, range_.startContainer)
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```

Observation

Dual-Task Learning between Variable Name and Type Prediction.

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Observation — *Dual-Task Learning between Variable Name and Type Prediction.*

Key Idea - I — *Variable Name Learning and Type Learning mutually benefit each other.*

Motivating Example

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Observation

The name and type of a variable are affected by the names and types of the surrounding variables in the code.

Motivating Example

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def exportSelection(self, root, doc):
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Observation

The name and type of a variable are affected by the names and types of the surrounding variables in the code.

Key Idea - II

"Tell Me Your Friends, I'll Tell You Who You Are"

We treat the problem of variable name and type generation as predicting the missing features in a graph neural network – leveraging Missing Feature Graph Convolutional Network (GCN_{MF}) for this purpose.

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def exportSelection(self, w, b):
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        d.selectNodeContents(w)
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          r.startContainer, r.startOffset)

                          ...

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          w, p, r.endContainer)

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```

Observation

The actual variable name must be in accordance with the names of the accessed fields and called methods.

Motivating Example

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def exportSelection(self, root, doc):
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Observation *The actual variable name must be in accordance with the names of the accessed fields and called methods.*

Observation *The fields and methods of a variable are kept intact after minification.*

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                        ...
```

Observation

The actual variable name must be in accordance with the names of the accessed fields and called methods.

Observation

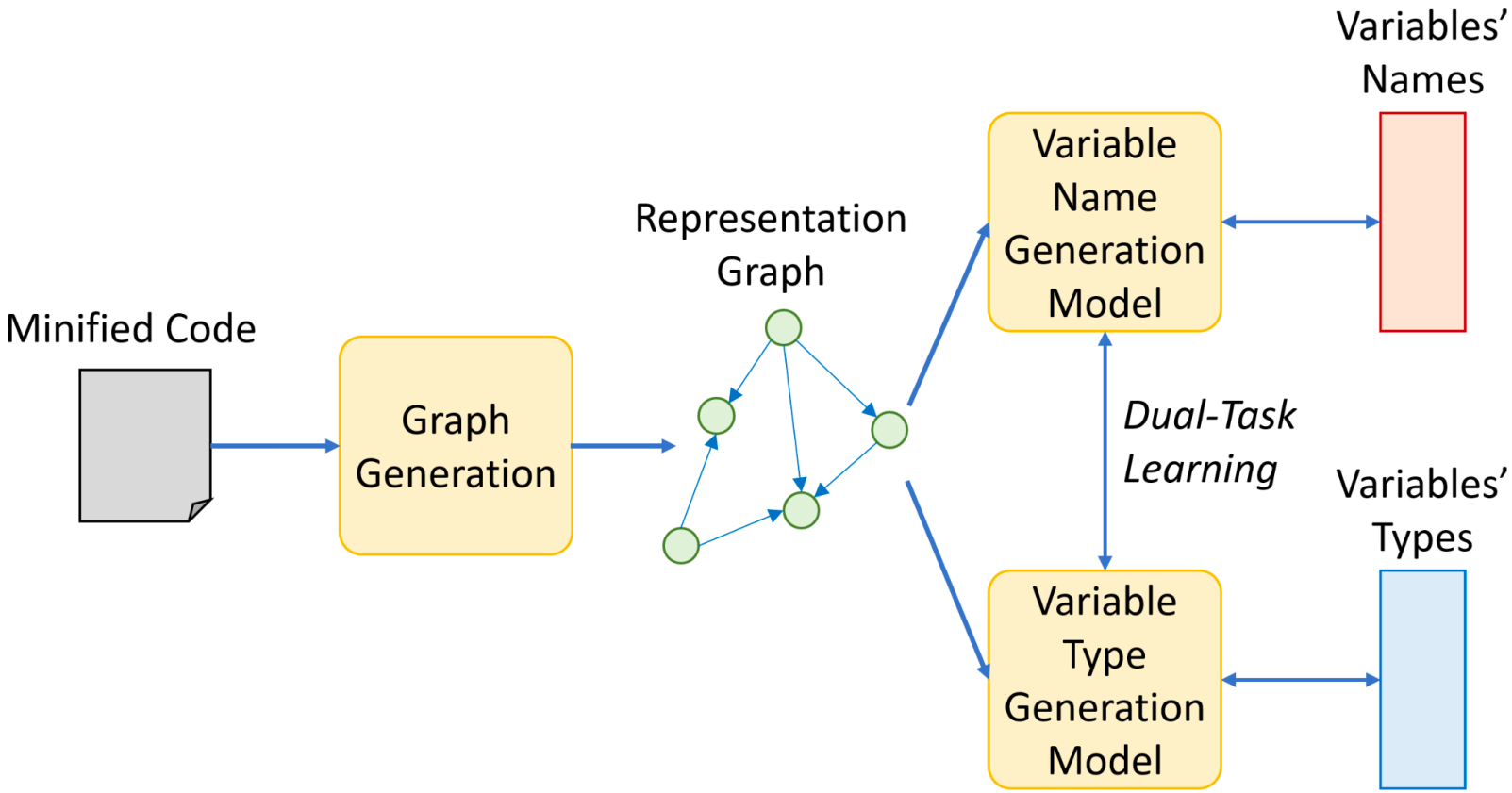
The fields and methods of a variable are kept intact after minification.

Key Idea - III

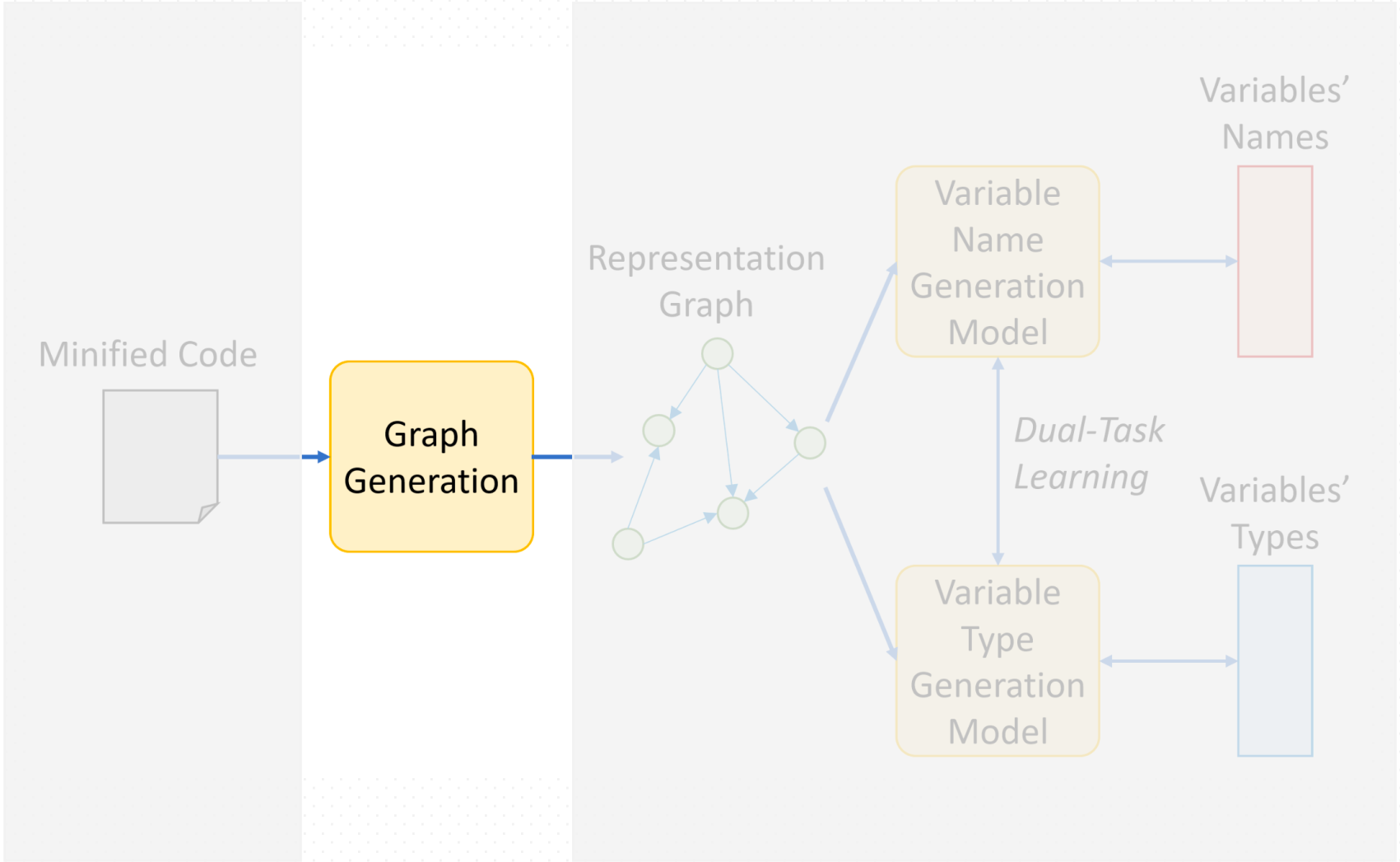
"Properties of a Variable"

The name of a variable is in accordance with its own properties.

DeMinify: Architecture Overview



DeMinify: Architecture Overview



Part I: Graph Generation

Given minified code, it is first parsed and two feature graphs are extracted:

- **Relation Graph** [1]
  - represents the relations among the variables including the ones via field accesses and method calls.

[1] Hieu Tran, Ngoc Tran, Son Nguyen, Hoan Nguyen, and Tien N. Nguyen. 2019. Recovering Variable Names for Minified Code with Usage Contexts. In Proceedings of the 41st International Conference on Software Engineering (Montreal, Quebec, Canada) (ICSE '19). IEEE Press, 1165–1175.

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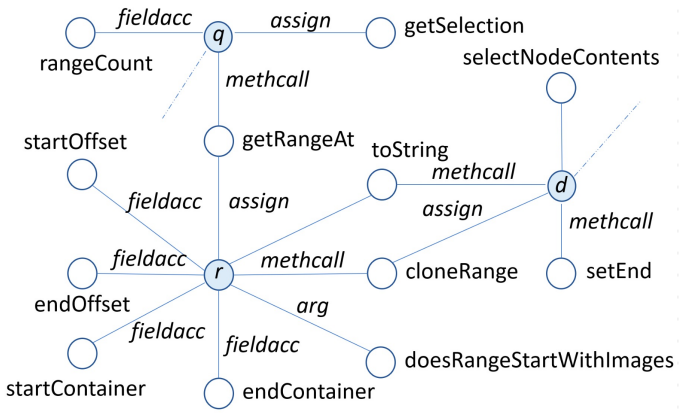

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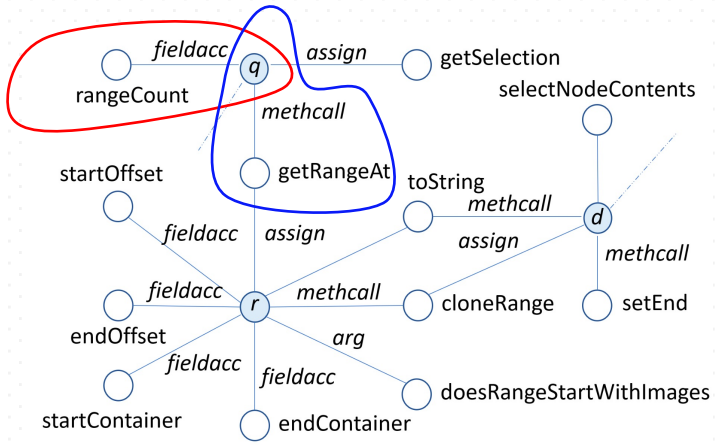
                          ...
```

Attribute and Behavior Triplets

< variable, field/method, fieldAccess/methodCall >



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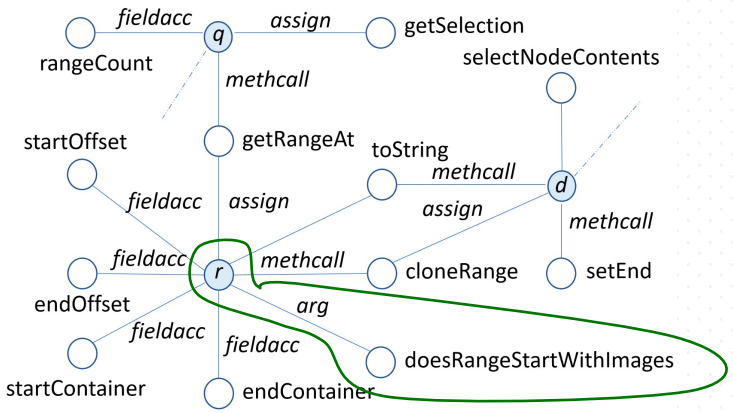
Argument Relation



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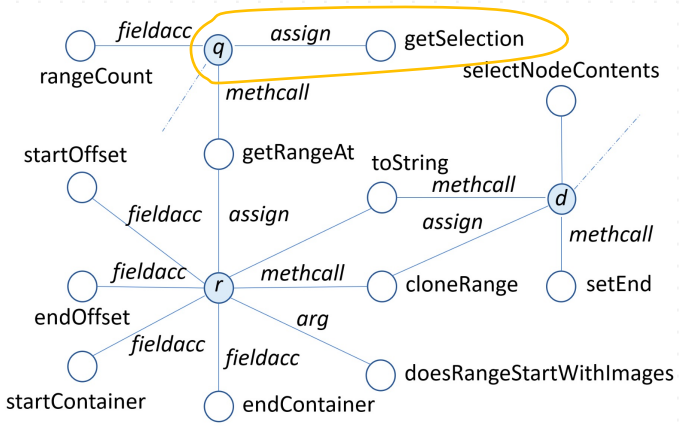
Assignment Relation



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Given minified code, it is first parsed and two feature graphs are extracted:

- **Relation Graph** [1]
  - represents the relations among the variables including the ones via field accesses and method calls.

- **Type Dependency Graph** [2]
  - represents the types of the variables in a function/method according to the type inference rules.

[2] Yun Peng, Cuiyun Gao, Zongjie Li, Bowei Gao, David Lo, Qirun Zhang, and Michael Lyu. 2022. Static Inference Meets Deep Learning: A Hybrid Type 1229 Inference Approach for Python. In Proceedings of the 44th International Conference on Software Engineering (Pittsburgh, Pennsylvania) (ICSE '22). Association for Computing Machinery, New York, NY, USA, 2019–2030.

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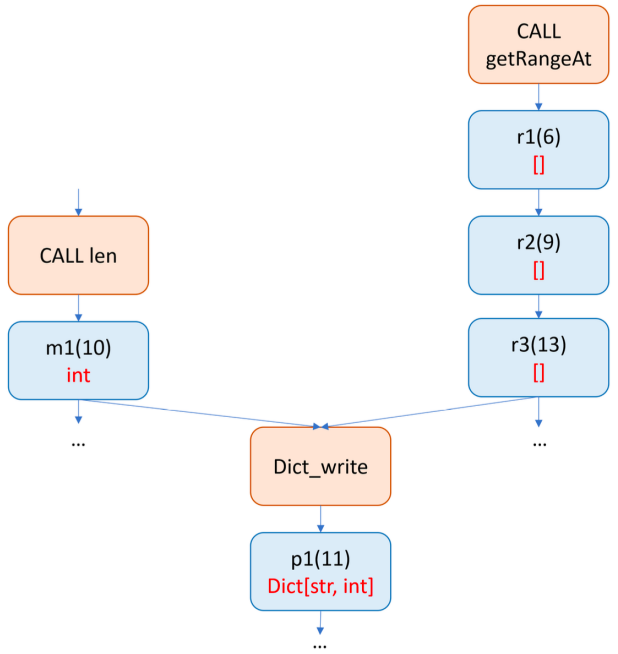
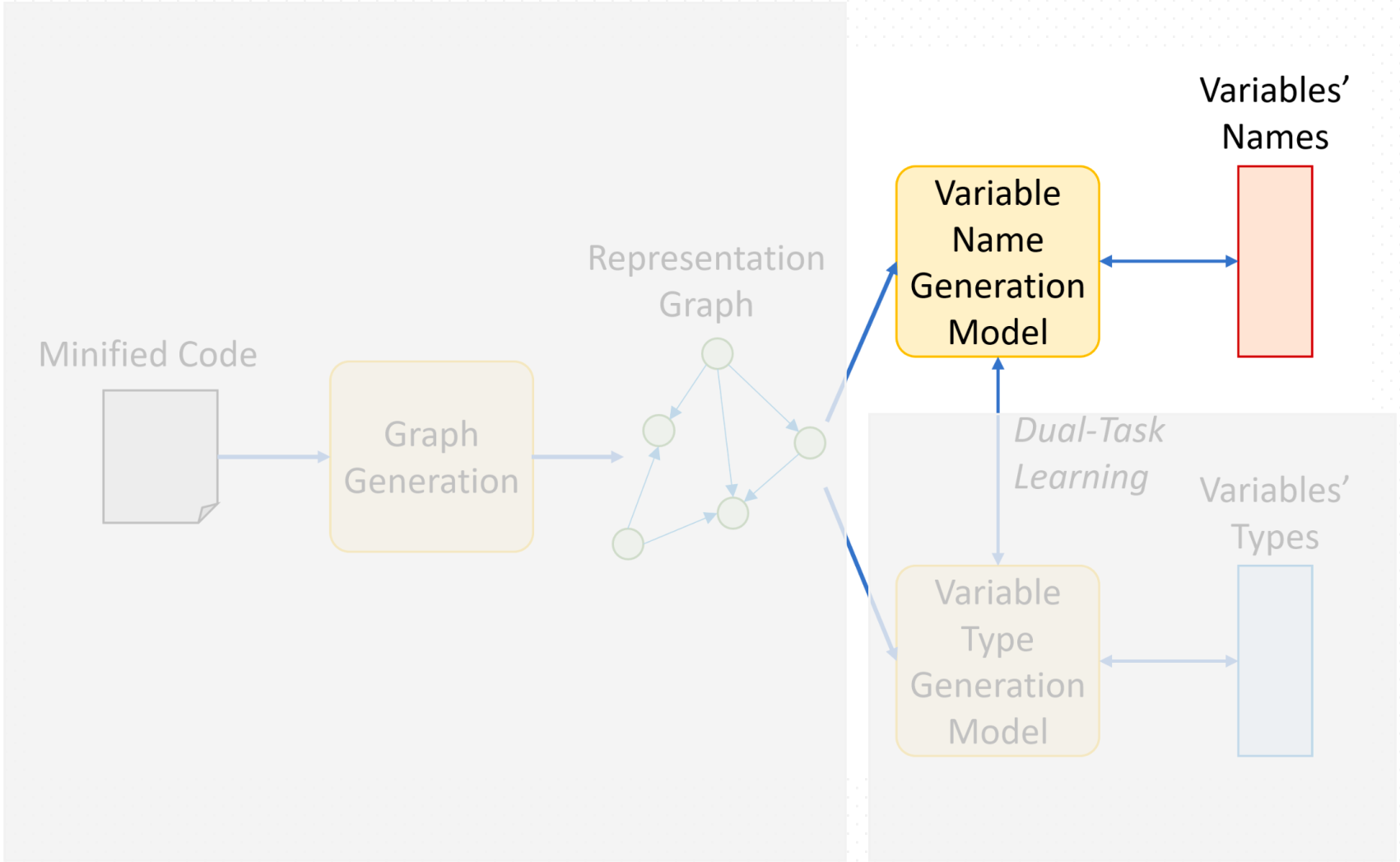
                              …
```

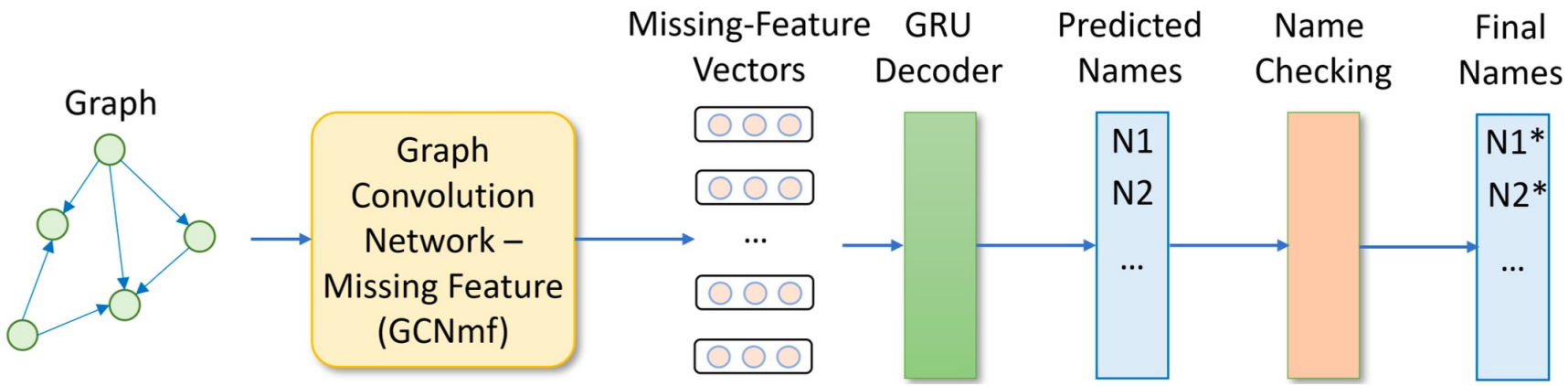


[2] Yun Peng, Cuiyun Gao, Zongjie Li, Bowei Gao, David Lo, Qirun Zhang, and Michael Lyu. 2022. Static Inference Meets Deep Learning: A Hybrid Type 1229 Inference Approach for Python. In Proceedings of the 44th International Conference on Software Engineering (Pittsburgh, Pennsylvania) (ICSE '22). Association for Computing Machinery, New York, NY, USA, 2019–2030.

DeMinify: Architecture Overview



Part II: Variable Name Generation



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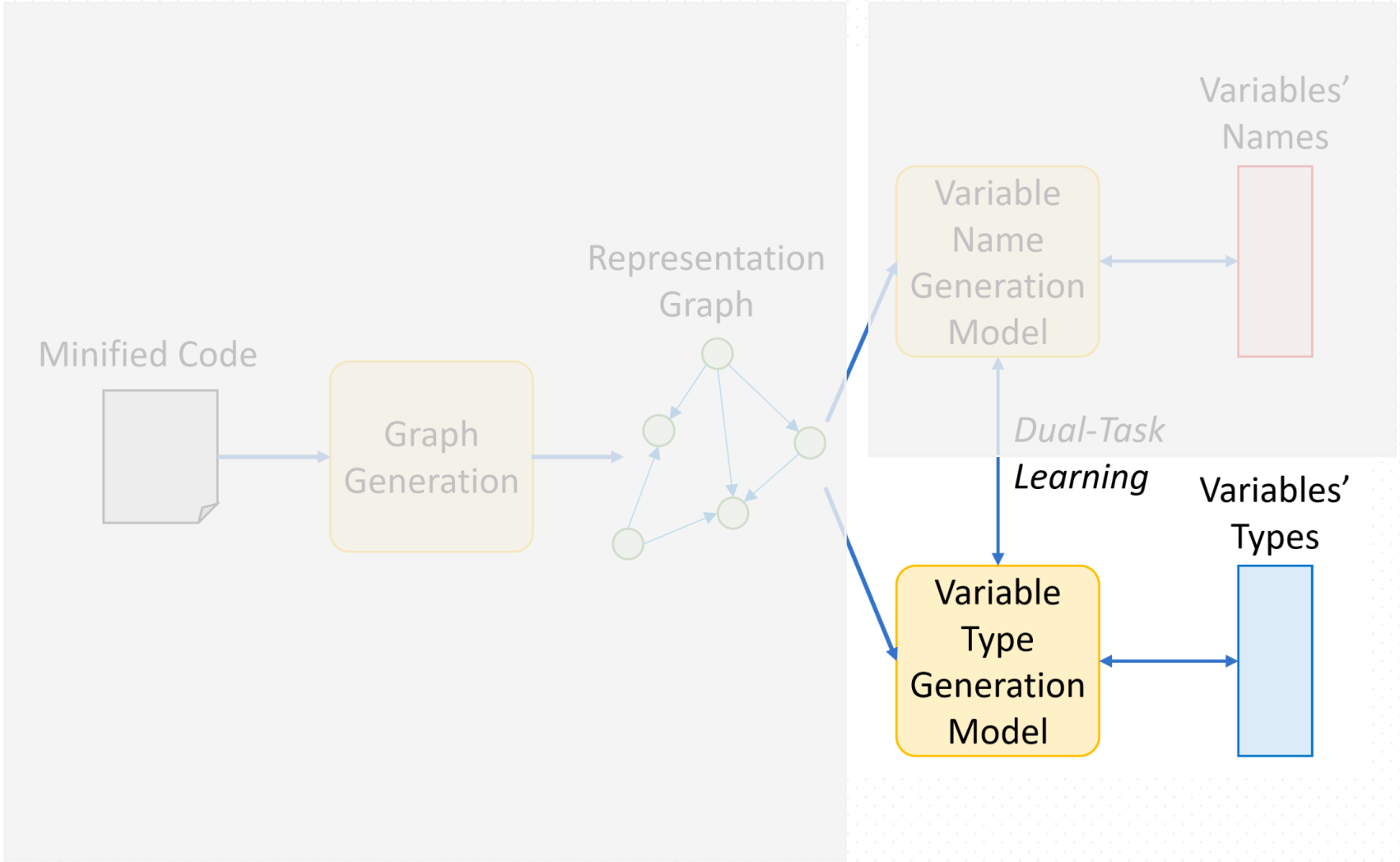

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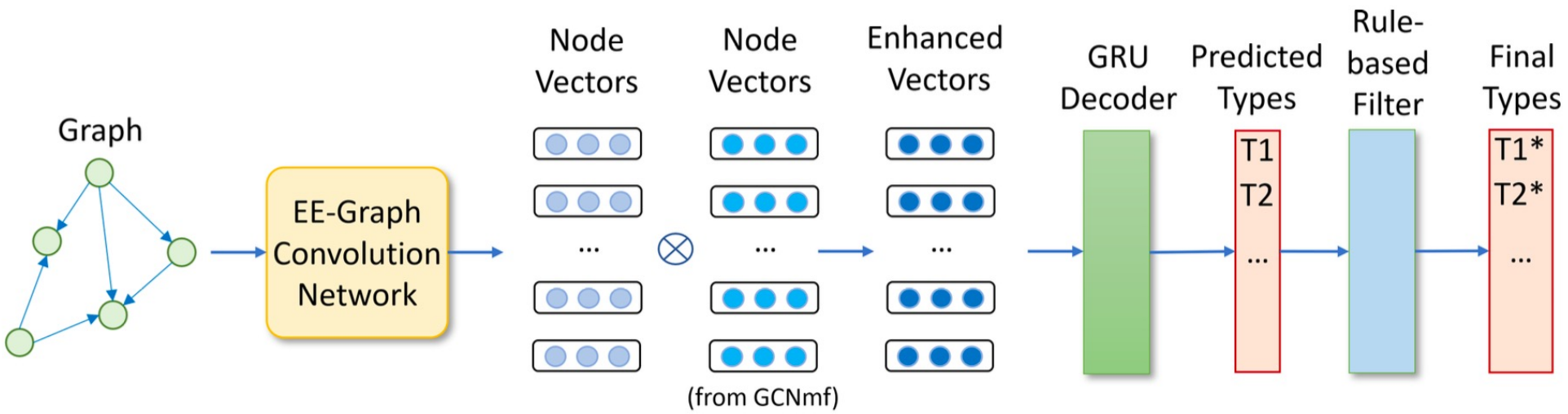

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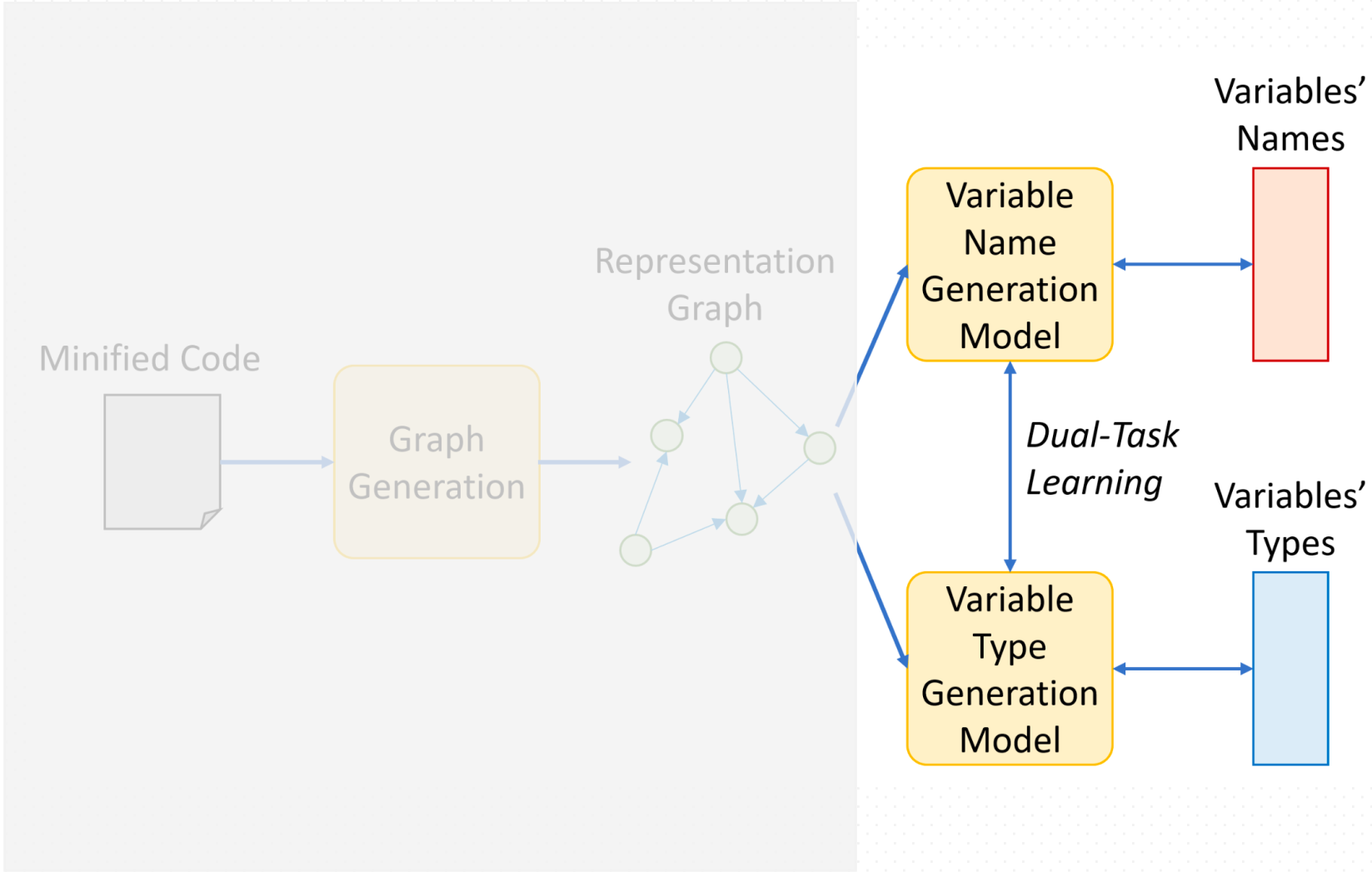

Empirical Evaluation (RQ1)

	Top-1		Top-3		Top-5	
	Local	All	Local	All	Local	All
JSNice [31]	41.6	54.5	52.2	63.0	59.5	67.8
JSNaughty [36]	48.3	59.6	59.8	69.7	66.3	75.0
JSNeat [34]	58.2	66.5	65.3	75.4	71.6	80.1
DeMinify	67.5	76.7	75.4	84.3	82.1	90.2

Table 1. Comparative Study on **Variable Name Prediction**

Empirical Evaluation (RQ1)

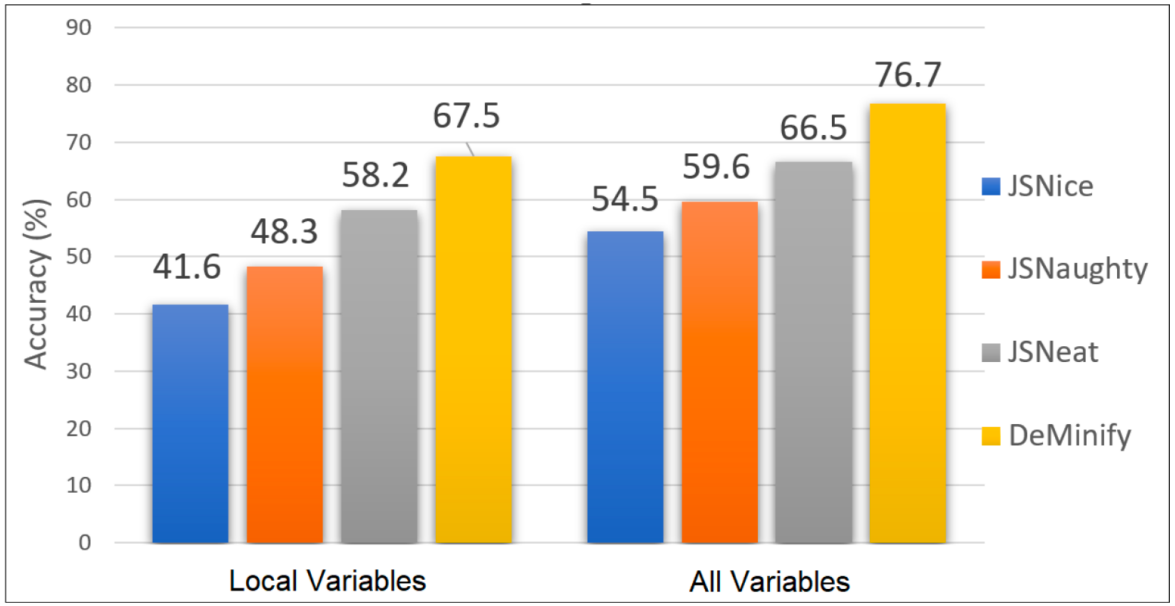

Figure. Top-1 Accuracy on **Variable Name Prediction**

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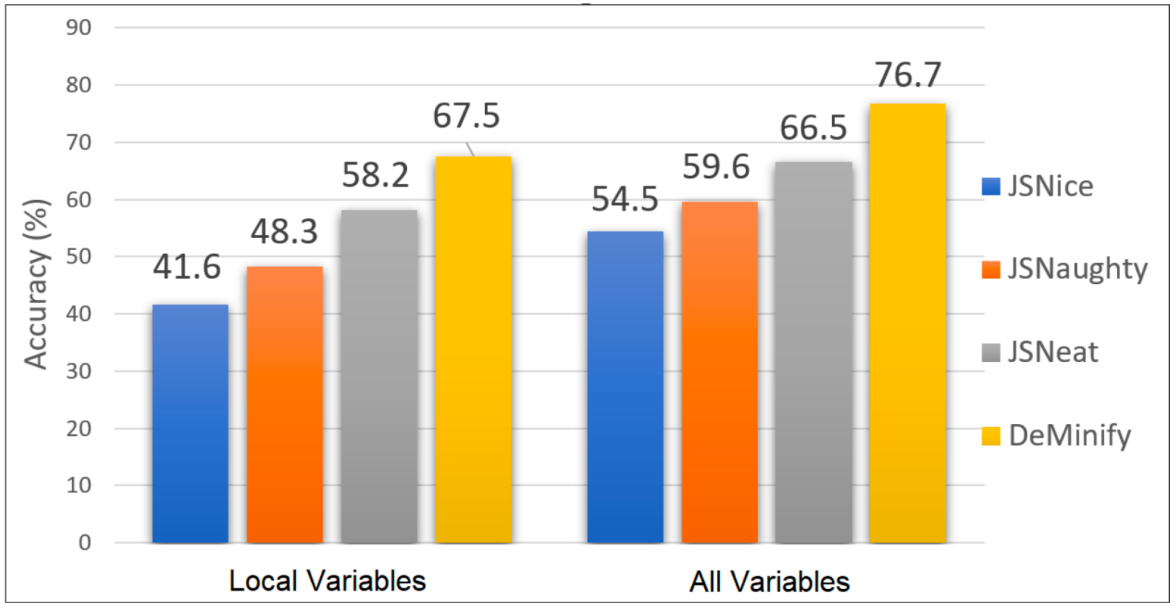

Figure. Top-1 Accuracy on **Variable Name Prediction**

DeMinify *improves over the state-of-the-art approaches for* ***predicting variable names*** *by* ***10.2% - 22.2%****.*

Empirical Evaluation (RQ2)

	Top-1		Top-3		Top-5	
	EM	PM	EM	PM	EM	PM
Ivanov *et al.* [15]	52	58	55	63	60	67
TypeWriter [27]	55	61	59	66	62	70
Typilus [4]	59	66	63	71	64	73
Type4Py [20]	62	66	66	72	67	73
HiTyper [24]	69	77	72	81	72	82
DeMinify	79	89	87	90	88	94

Table 2. Comparative Study on **Variable Type Prediction**

Empirical Evaluation (RQ2)

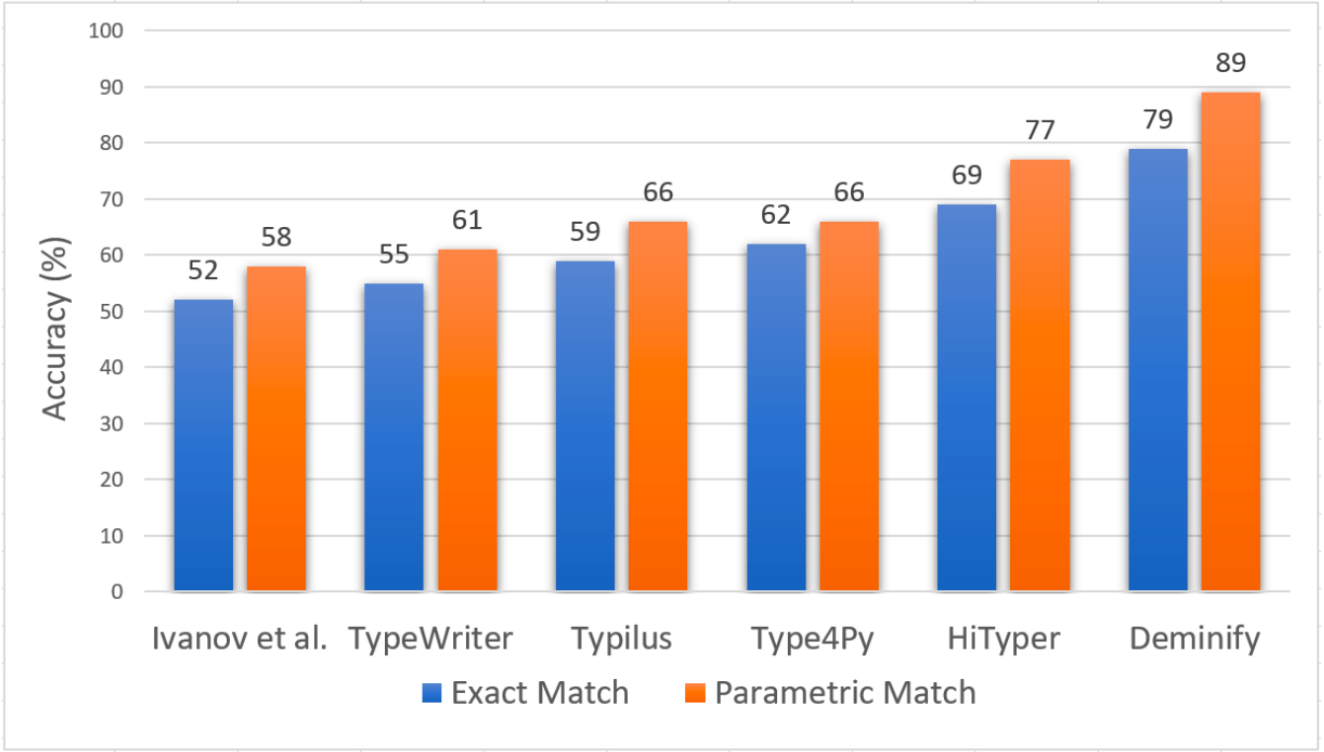

Figure. Top-1 Accuracy on **Variable Type Prediction**

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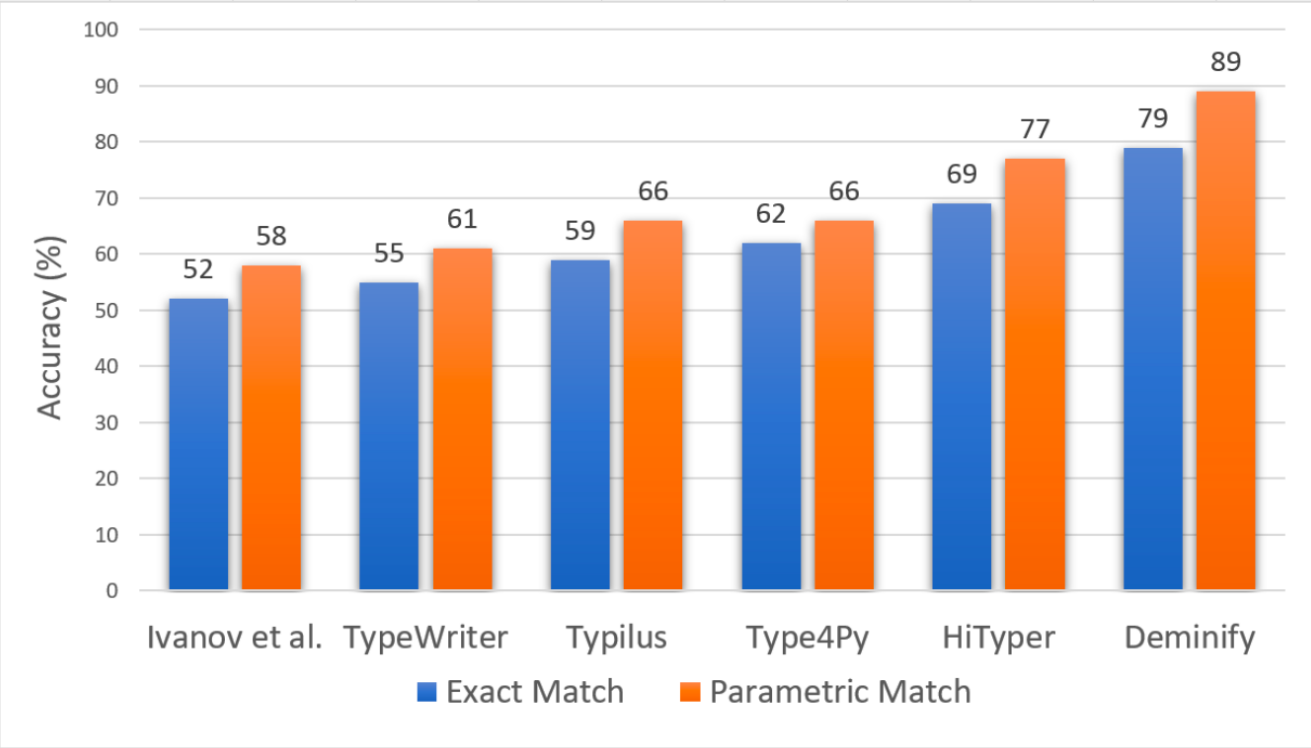

Figure. Top-1 Accuracy on **Variable Type Prediction**

DeMinify *improves over the state-of-the-art approaches for* ***predicting variable types*** *by* ***10% - 27%****.*

Empirical Evaluation (RQ3)

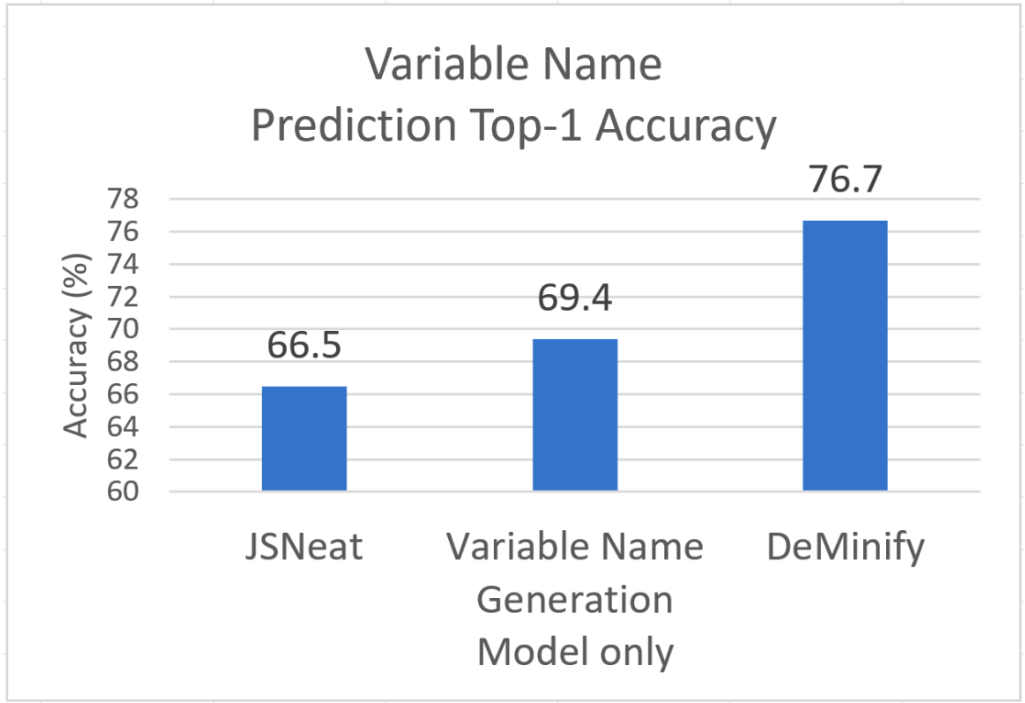

Figure. Impact of Dual-Task Learning on **Variable Name Prediction** (*left*)

Empirical Evaluation (RQ3)

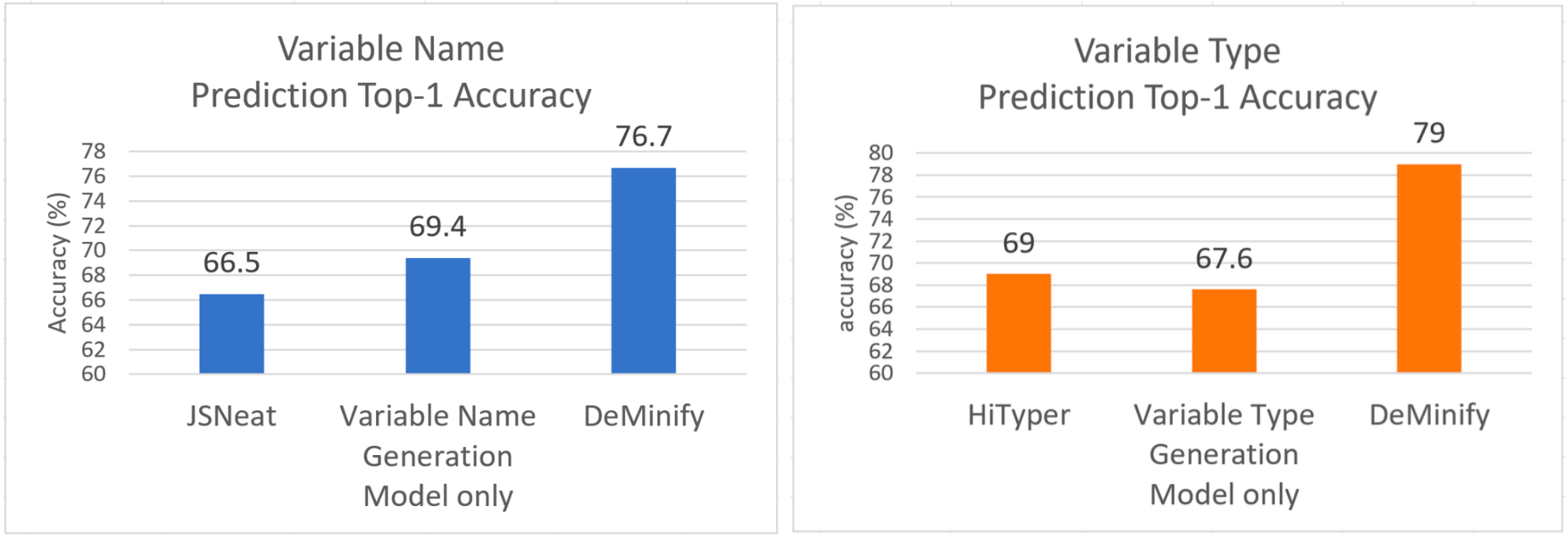

Figure. Impact of Dual-Task Learning on **Variable Name Prediction** (*left*), and **Variable Type Prediction** (*right*).

Empirical Evaluation (RQ3)

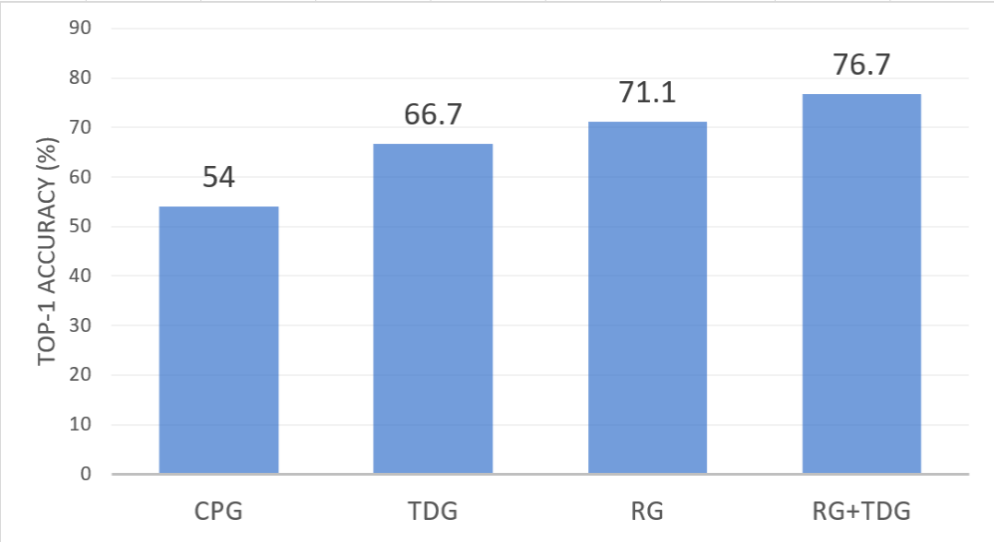

Figure. Impact of input graphs on **Variable Name Prediction** (*left*)
Here, **CPG**: Code Property Graph, **TDG**: Type Dependency Graph, **RG**: Relation Graph

Empirical Evaluation (RQ3)

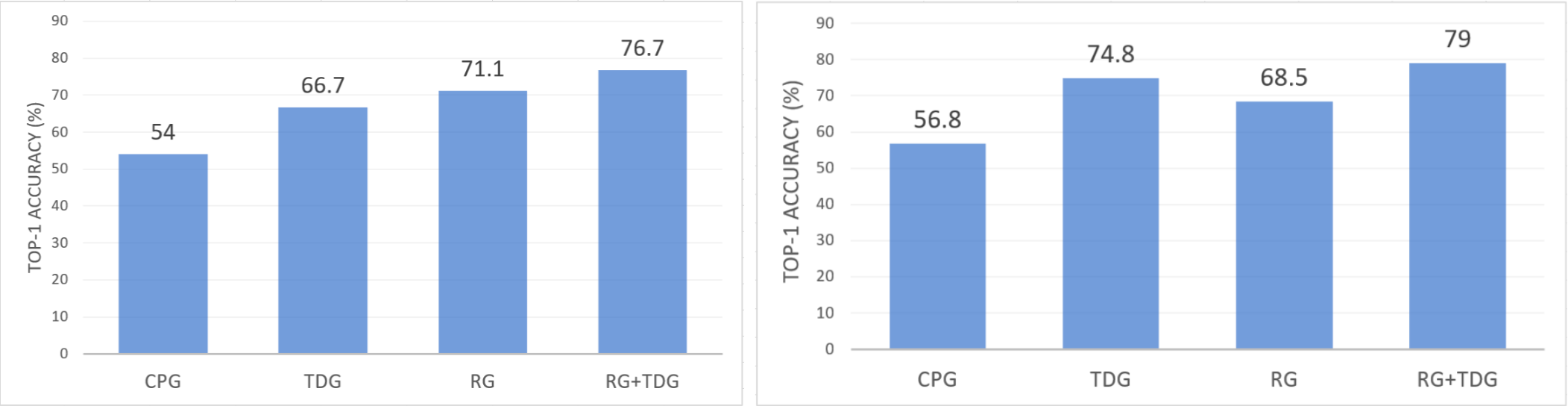

Figure. Impact of input graphs on **Variable Name Prediction** (*left*), and **Variable Type Prediction** (*right*).
Here, **CPG**: Code Property Graph, **TDG**: Type Dependency Graph, **RG**: Relation Graph

DeMinify in Action

```
1  def get(self, request):
2    client_ip = self.extract_ip_from(request)
3    is_limited = self.check_request_limit(client_ip)
4    if is_limited:
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6    count = BirdNameDatabase.objects.count() - 1
7    index = randint(0, count)
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Figure. Python code listing **correctly** deobfuscated by DeMinify

Conclusion

Scan QR code to access the replication package, data, and supplementary material.

Background

- When the source code needs to be executed on the client side, it is often obfuscated, replacing the variable names with short, opaque, and meaningless names.
- The minification of variable names in this manner helps hide the business logic from the readers.

```
def exportSelection(self, root, doc):
    if not root:
        return null
    selection = doc.getSelection()
    if selection.rangeCount > 0:
        range_ = selection.getRangeAt(0)
                    ...
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Figure. An original code snippet from a project in GitHub (*left*), and its minified version (*right*).

- The deminification of the same too, is highly relevant in reverse engineering, helping cybersecurity and software analysts identify potentially malicious code.

usion

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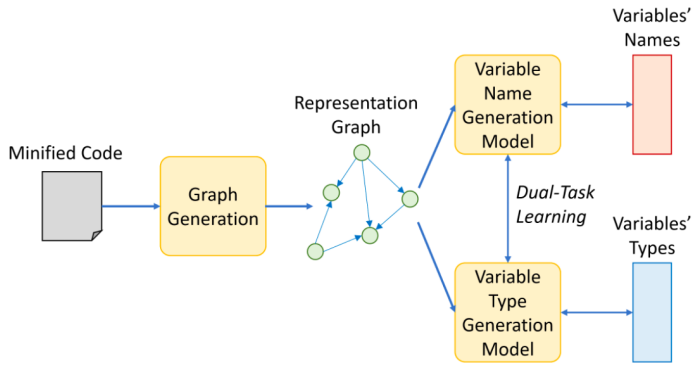

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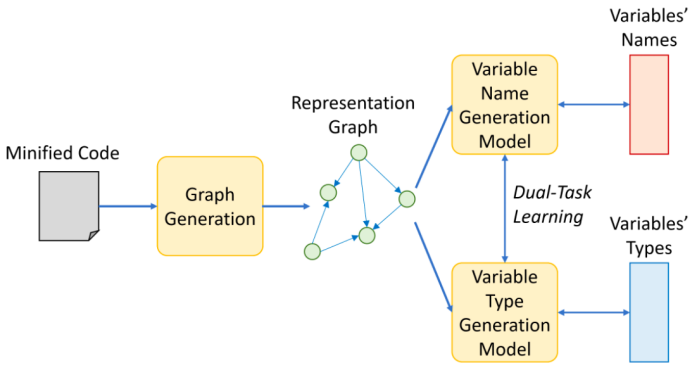

Empirical Evaluation

- DeMinify *improves over the state-of-the-art approaches for* ***predicting variable names*** *by* ***10.2% - 22.2%***.
- DeMinify *improves over the state-of-the-art approaches for* ***predicting variable types*** *by* ***10% - 27%***.
- *All model components and design choices in* DeMinify *contribute to an improved performance in both variable name and type prediction.*

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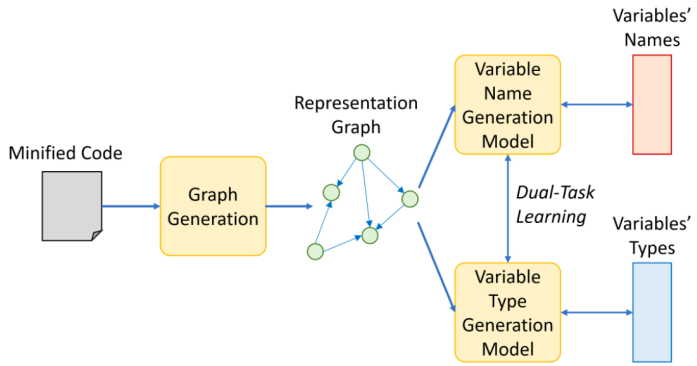

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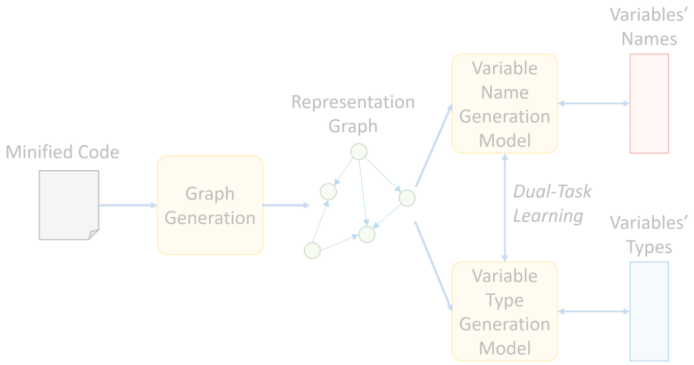

Thank you!

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EXTRA SLIDES

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