Toward the Automated Localization of Buggy Mobile App UIs from Bug Descriptions

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WILLIAM & MARY
CHARTERED 1693

UCF
UNIVERSITY OF CENTRAL FLORIDA

GEORGE MASON UNIVERSITY

Problem Motivation



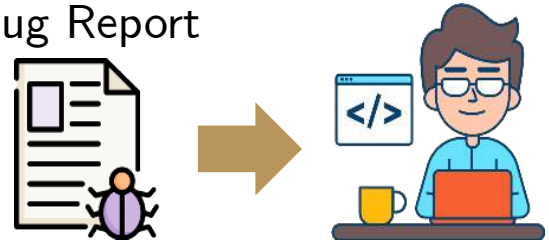
Problem Motivation

Bug Report



Problem Motivation

Bug Report



Problem Motivation

Bug Report





Android App



Problem Motivation

Bug Report





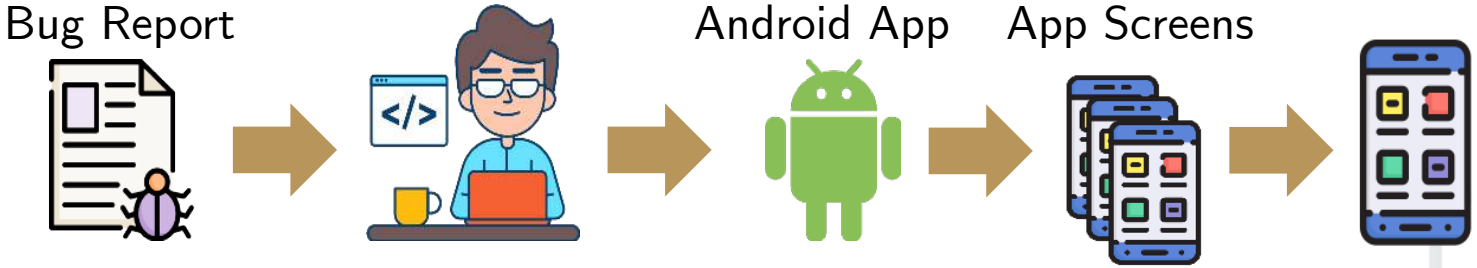
Android App



App Screens



Problem Motivation



Problem Motivation



Problem Motivation



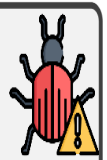
Example



Example

WifiAnalyzer App

Title: Can no longer enter text in SSID Filter TextView



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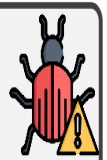

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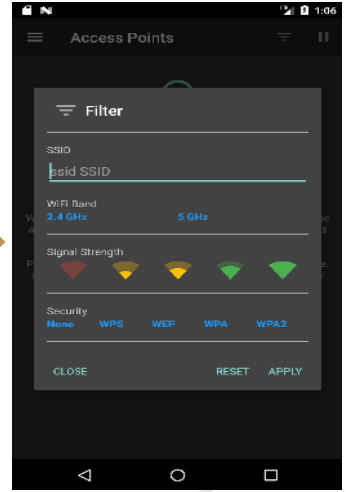

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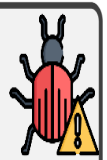

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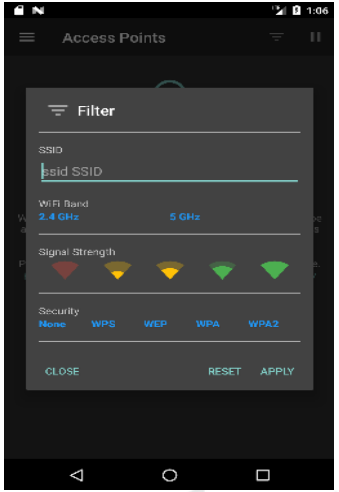

Buggy UI Screen

Example

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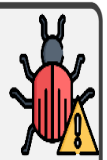

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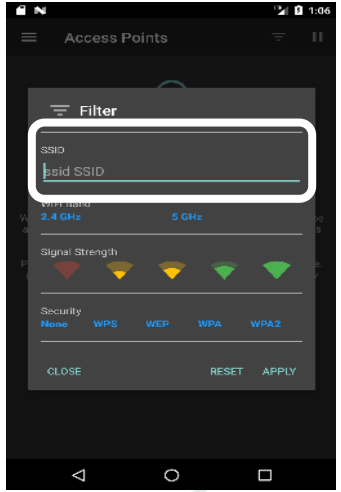

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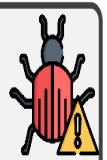

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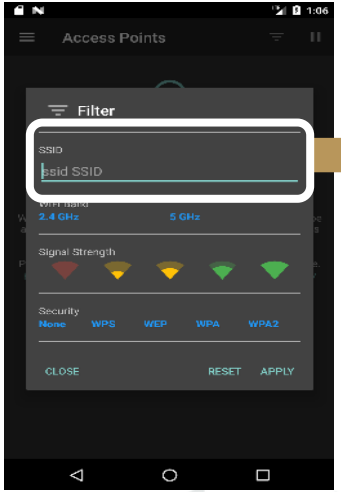

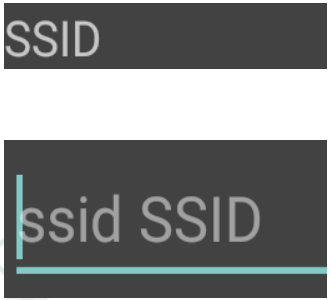

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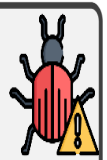

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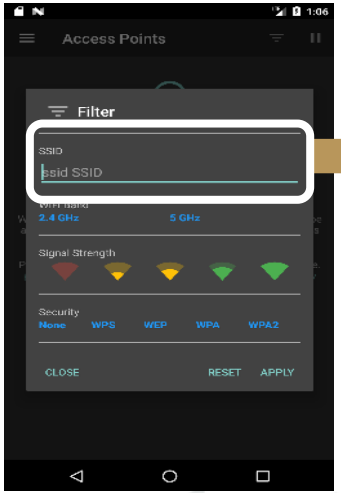

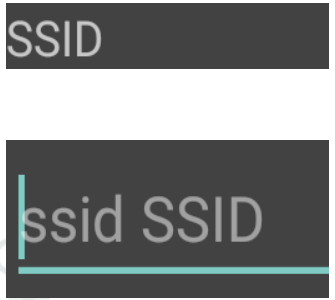

Buggy UI Screen

Buggy UI Component

Example

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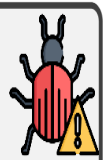

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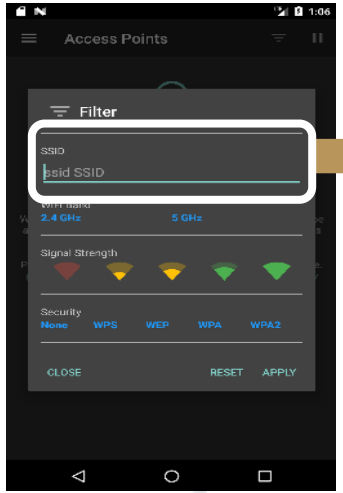
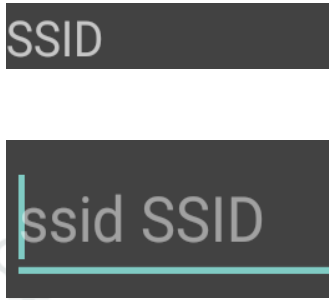




Observed Behavior (OB)
OR
Bug Descriptions

Buggy UI Screen

Buggy UI Component

Problem Motivation



Problem Motivation

Why is manual localization of Buggy UI difficult?



Problem Motivation

Why is manual localization of Buggy UI difficult?

Low-Quality Bug Report

Bug Report





Problem Motivation

Why is manual localization of Buggy UI difficult?

Low-Quality Bug Report

Bug Report



Large Number of App Screens



Problem Motivation

Why is manual localization of Buggy UI difficult?

Low-Quality Bug Report

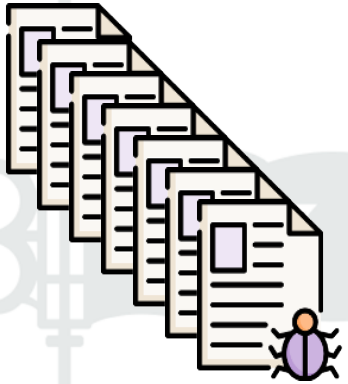
Bug Report



Large Number of App Screens



Volume of Reported Bugs



Automated Buggy UI Localization

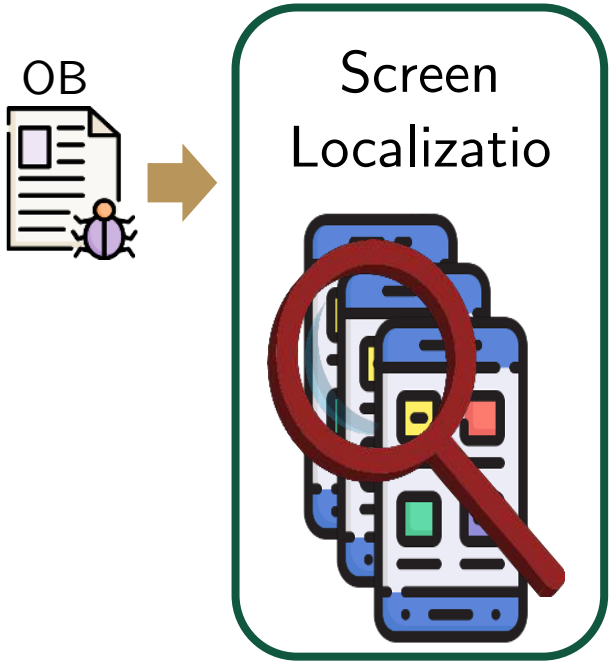


Automated Buggy UI Localization

Screen Localizatio



Automated Buggy UI Localization



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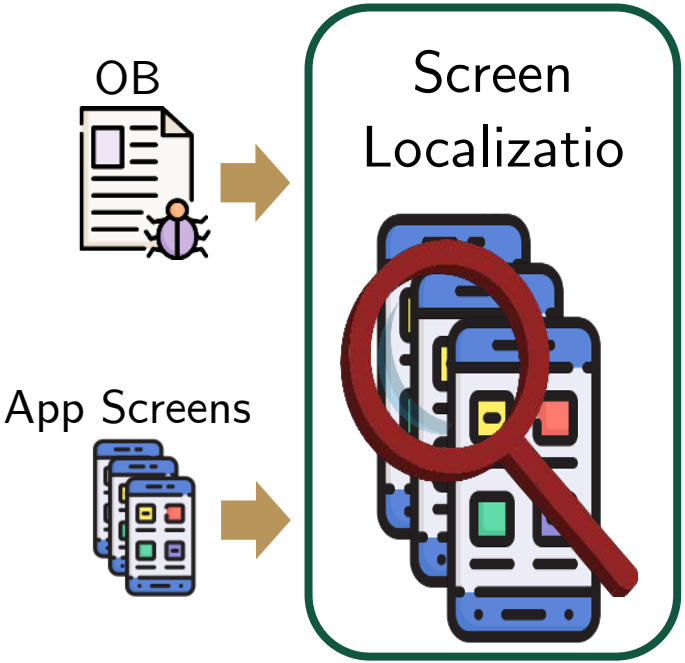

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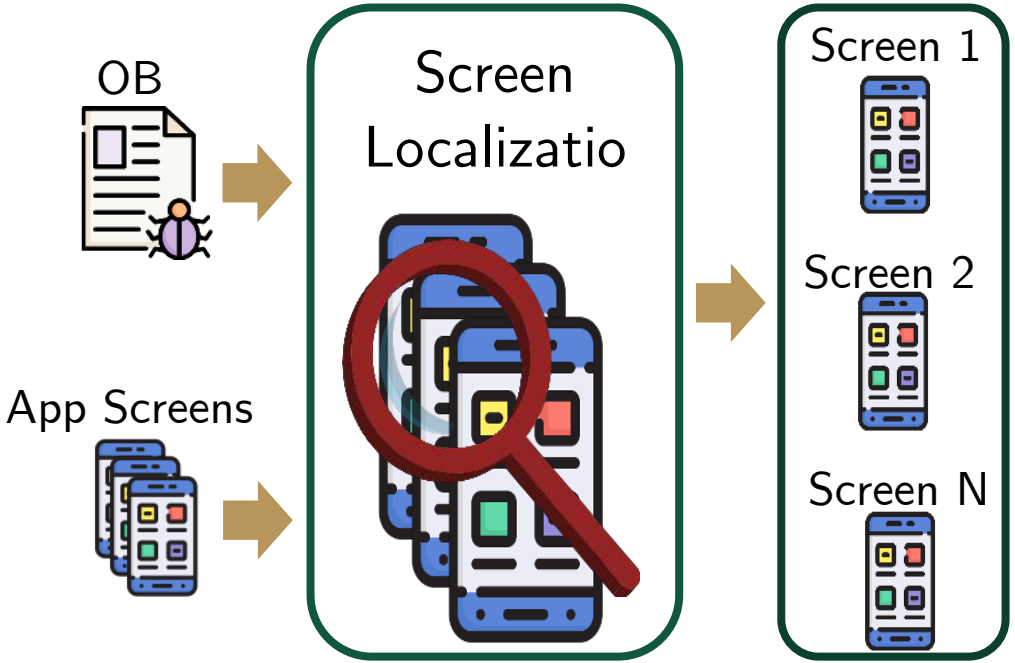

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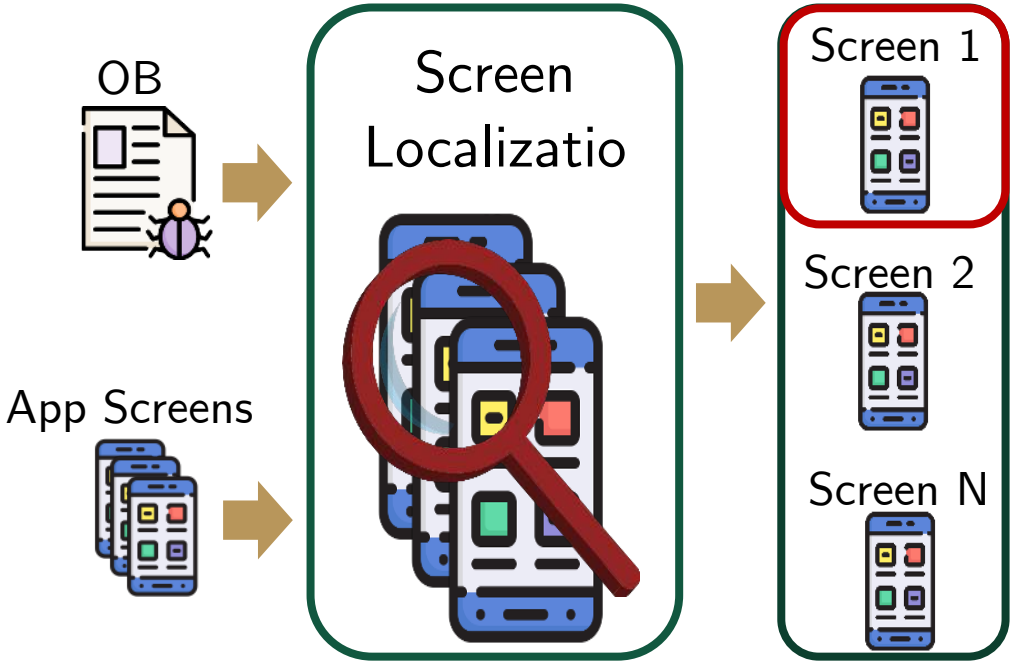

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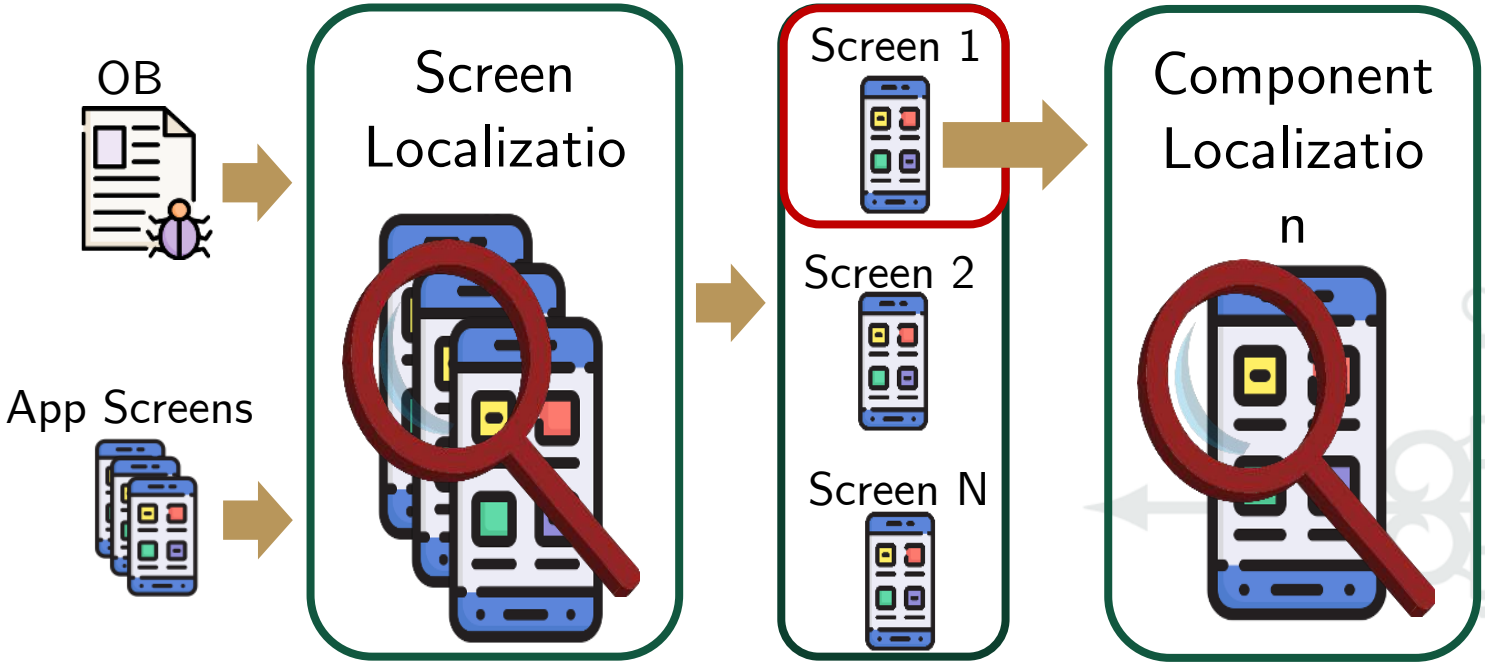

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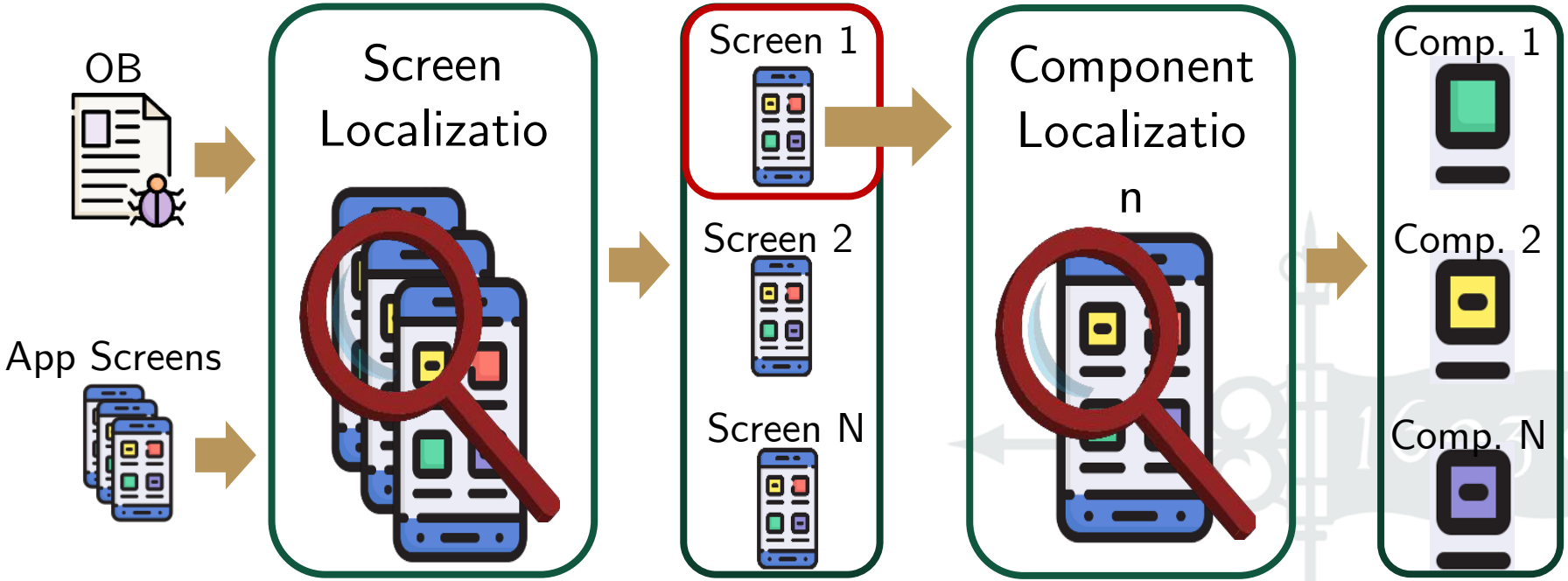
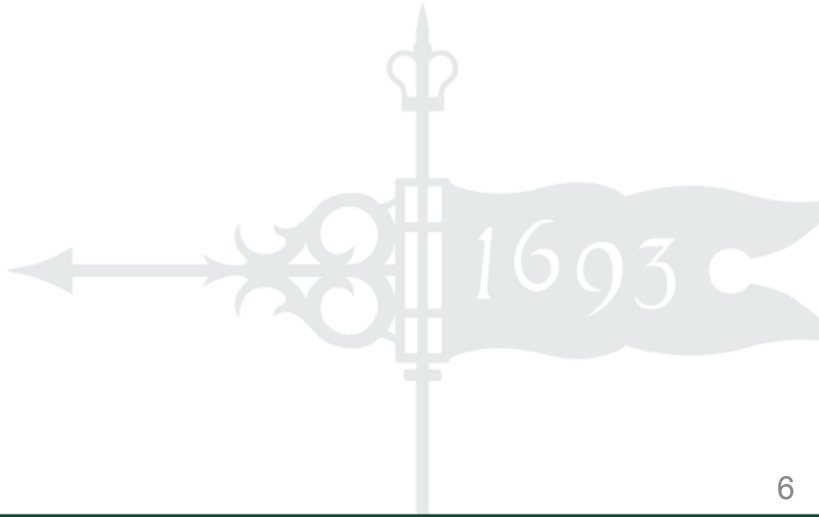


How?



How?

Information Sources for Buggy UI Localization



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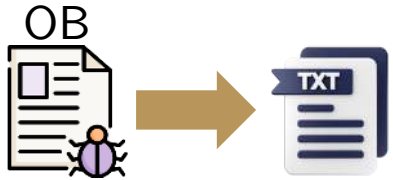

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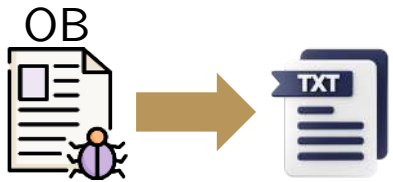

Android App



How?

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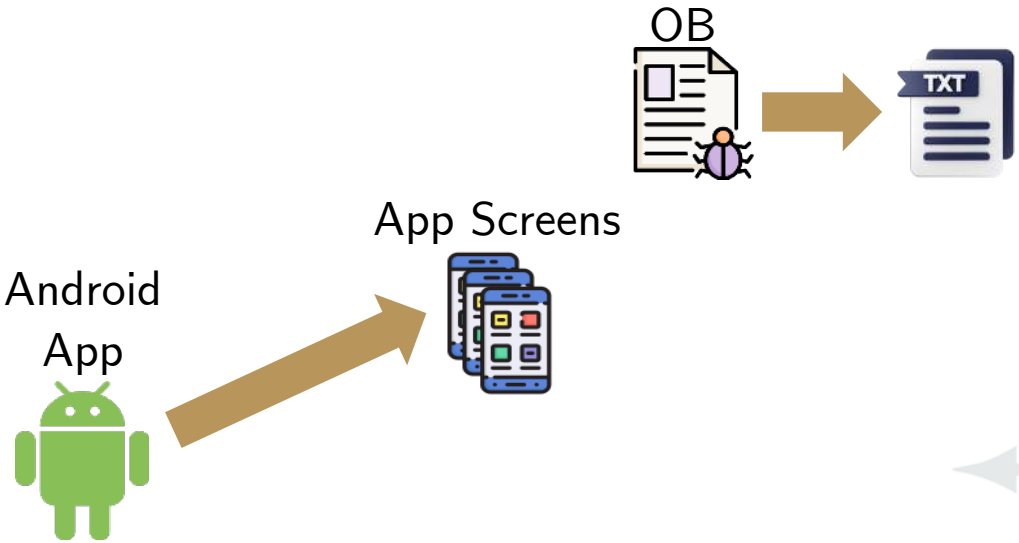

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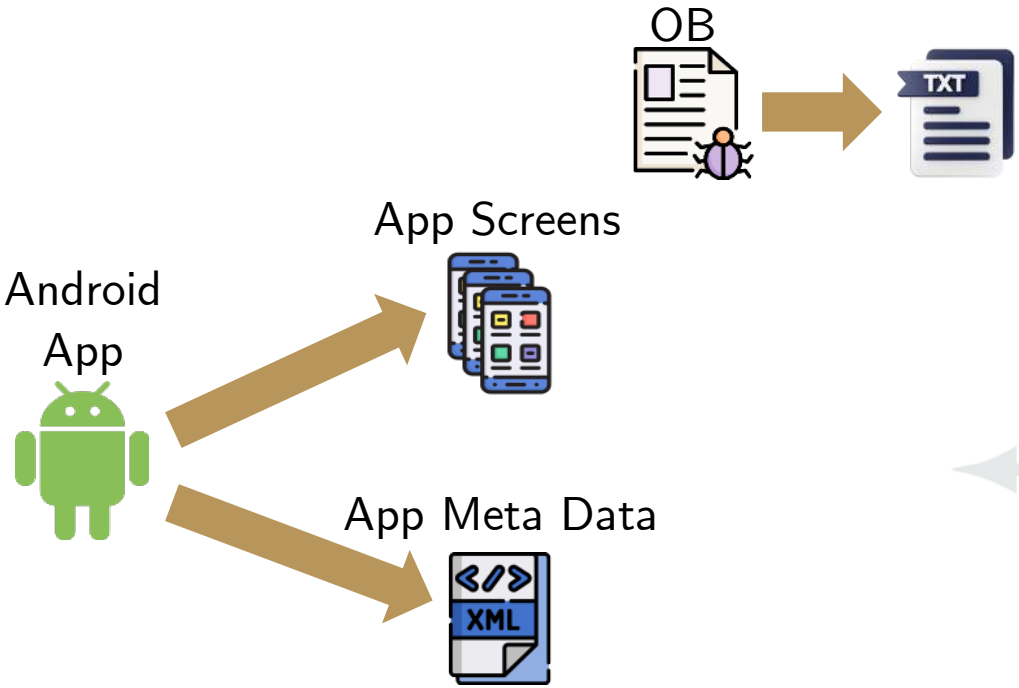

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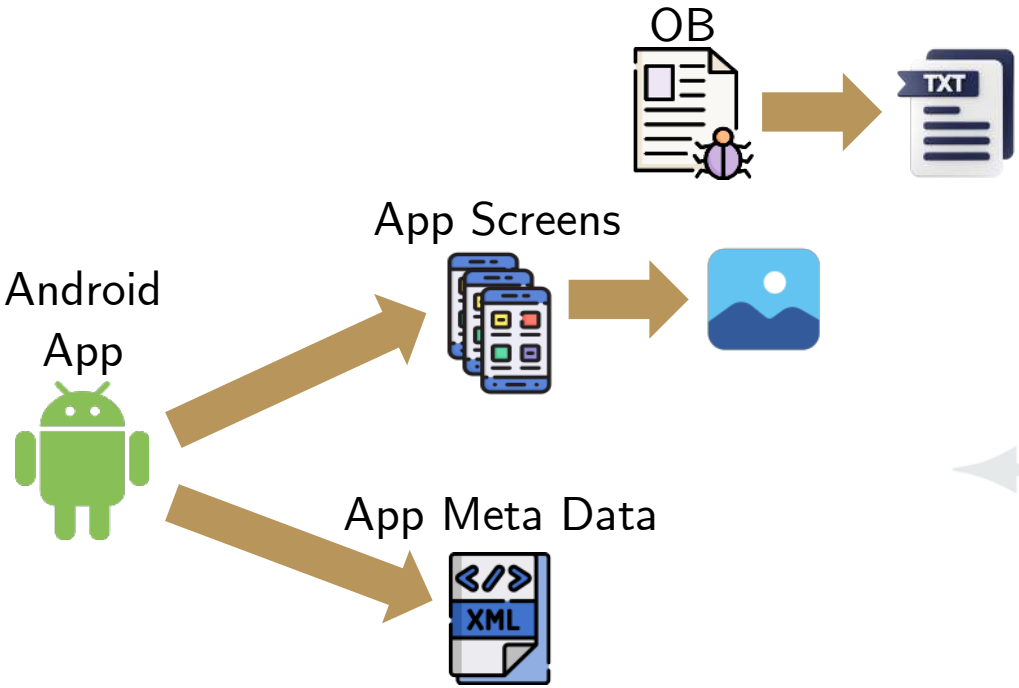

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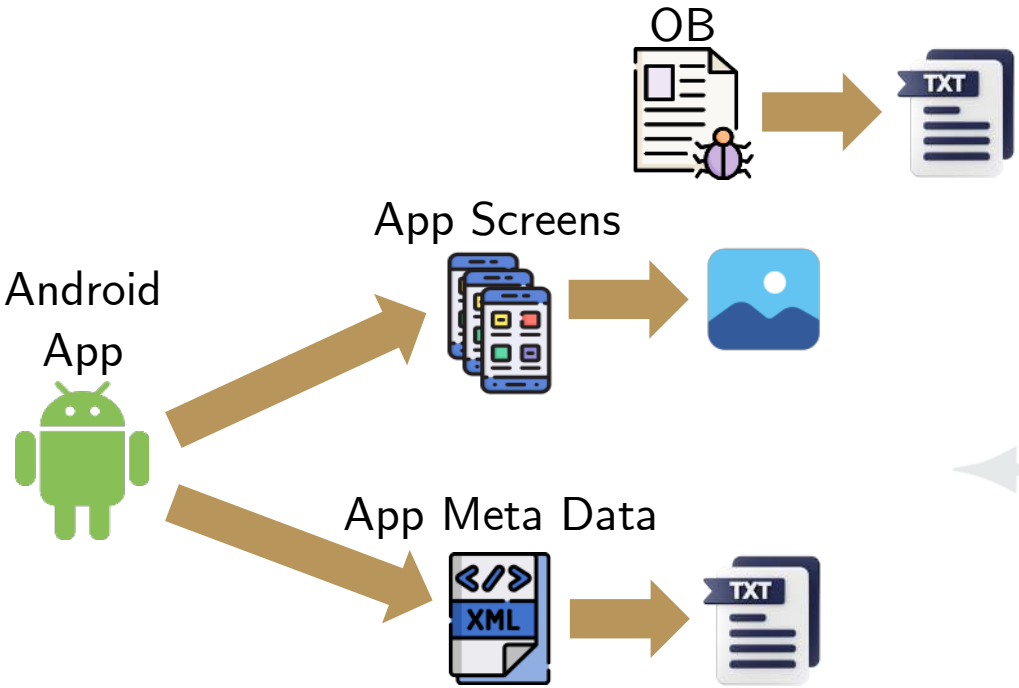

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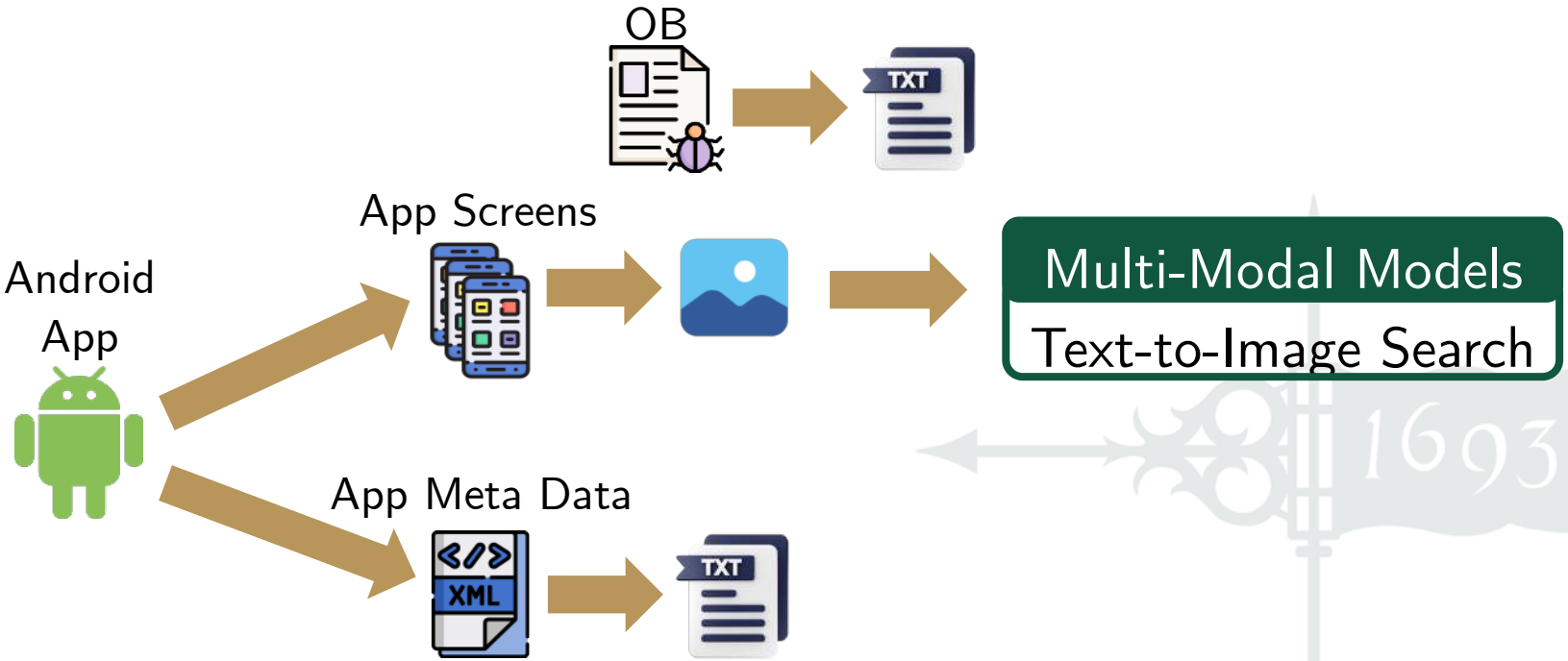

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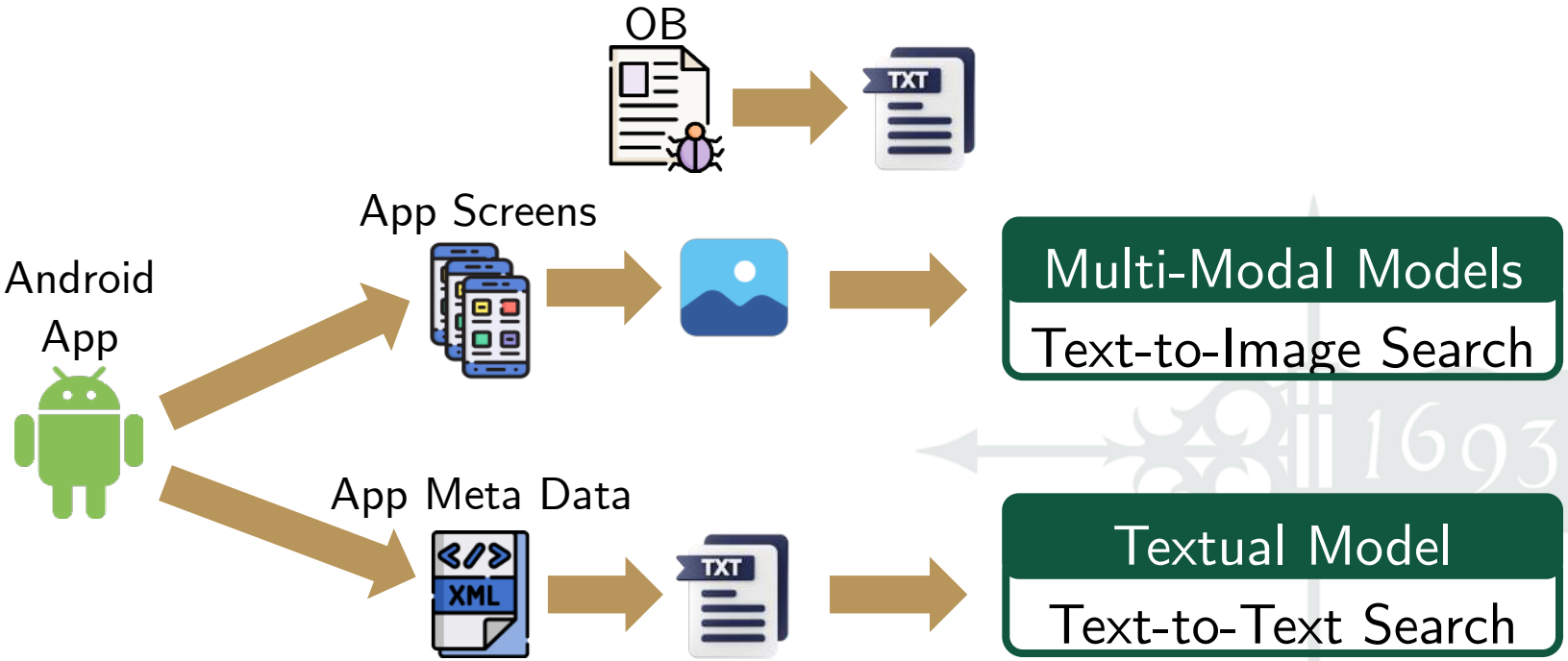


Study Goal & RQs



Study Goal & RQs

Goal

Investigate the Feasibility of Buggy UI Localization Using Existing Retrieval Approaches



Study Goal & RQs

Goal

Investigate the Feasibility of Buggy UI Localization Using Existing Retrieval Approaches

RQs

1. Effectiveness of Approaches for Screen Localization (SL)?
2. Effectiveness of Approaches for Component Localization (CL)?
3. Effectiveness of Approaches for Different Query Quality?

Retrieval Approaches



Retrieval Approaches



Unsupervised TF-IDF-Based Textual Model

Retrieval Approaches



Unsupervised TF-IDF-Based Textual Model

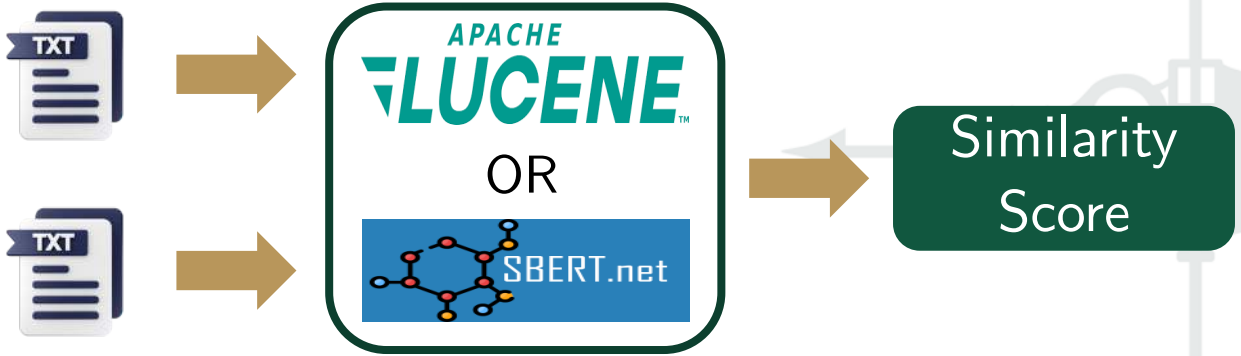


Neural BERT-Based Textual Language Model

Retrieval Approaches

Unsupervised TF-IDF-Based Textual Model

Neural BERT-Based Textual Language Model



Retrieval Approaches



Retrieval Approaches



CLIP Neural Multi-modal Vision-Language Model

Retrieval Approaches


CLIP Neural Multi-modal Vision-Language Model

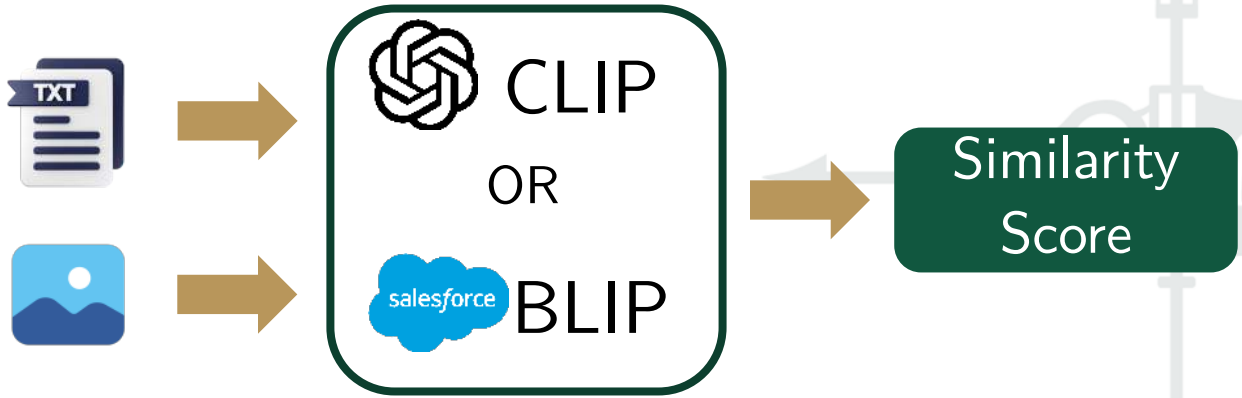


BLIP Neural Multi-modal Vision-Language Model

Retrieval Approaches

CLIP — Neural Multi-modal Vision-Language Model

BLIP — Neural Multi-modal Vision-Language Model



Dataset Construction



Dataset Construction

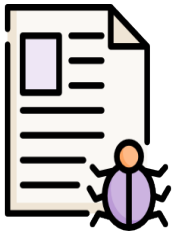


Query

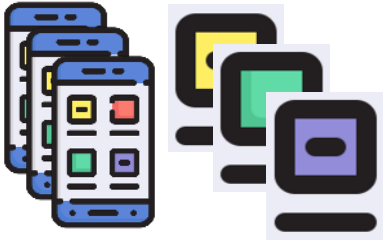
228 (SL)
254 (CL)

Dataset Construction

OB



App Screens/Comps.

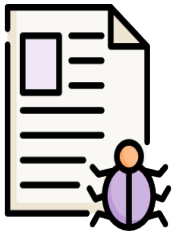


Query
228 (SL)
254 (CL)

Corpus
26 Per App (SL)
17 Per Screen (CL)

Dataset Construction

OB



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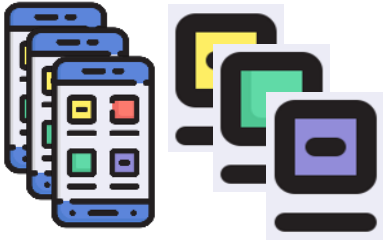


Buggy Screens/Comps.



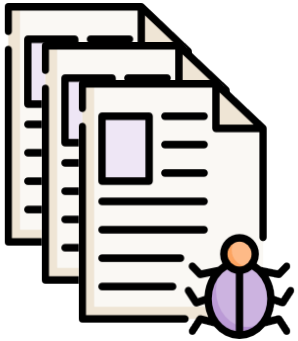
Query	Corpus	Ground Truth
228 (SL) 254 (CL)	26 Per App (SL) 17 Per Screen (CL)	2.1 Per Query (SL) 1.9 Per Query (CL)

Bug Report Selection



Bug Report Selection

87 Bug Reports[1, 2]



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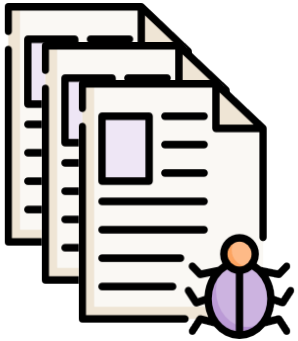
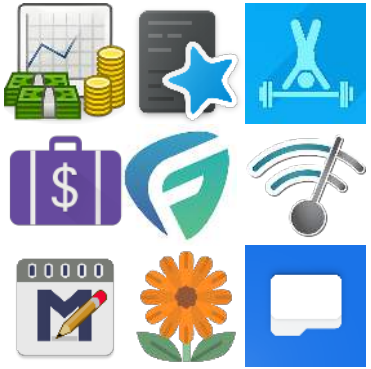


39 Android Apps



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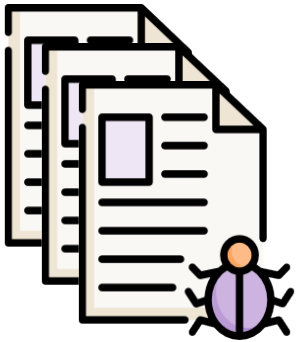

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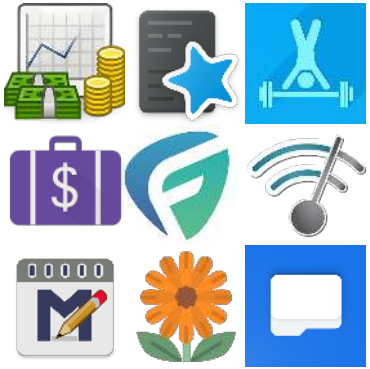

Various Bug Types

- UI Cosmetic Issue
- App Crash
- Output Problem

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Retrieval Corpus Collection



Retrieval Corpus Collection

Collect screenshots & metadata of UI screens/components



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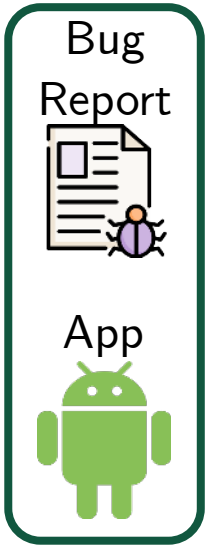

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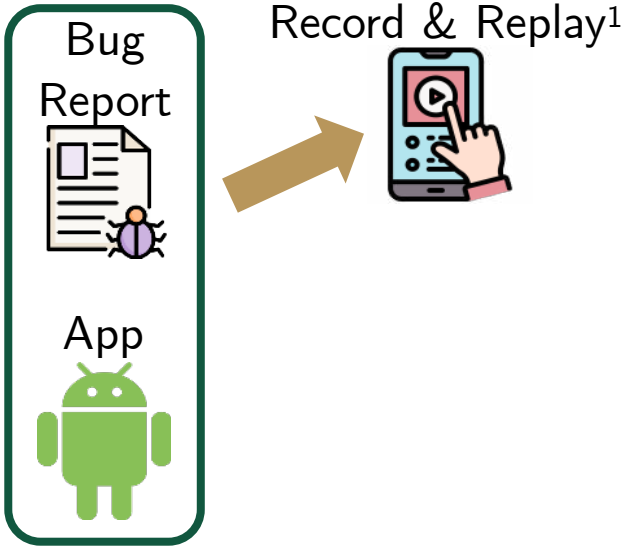

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Retrieval Corpus Collection

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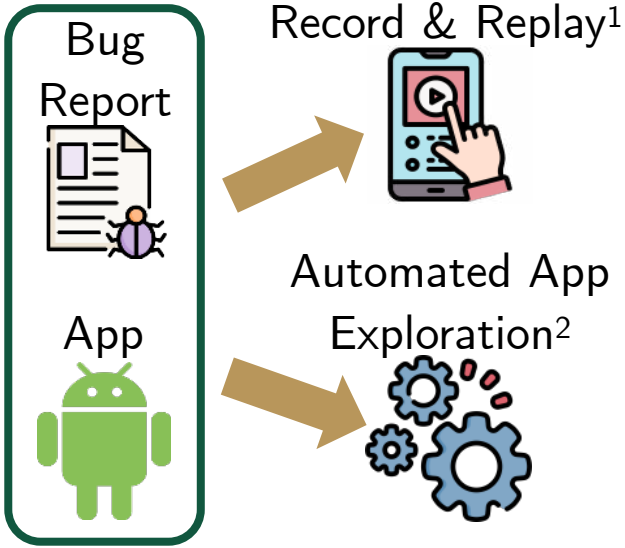

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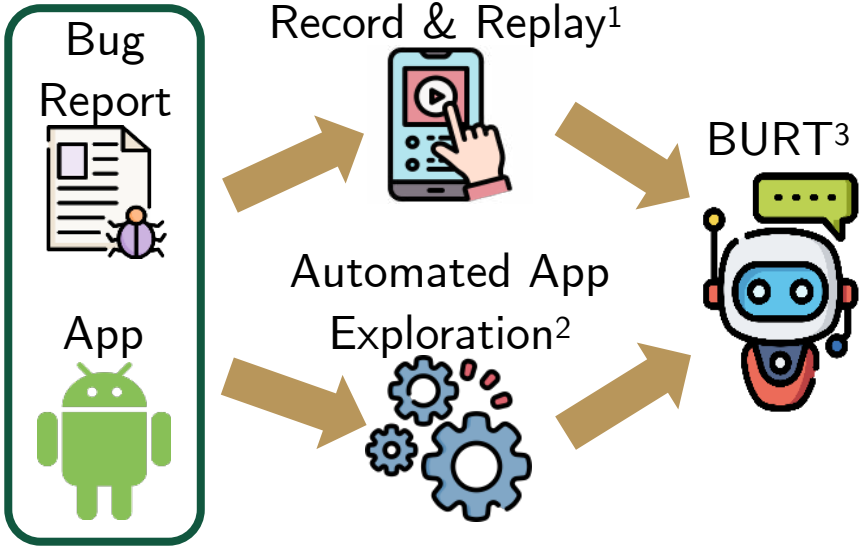

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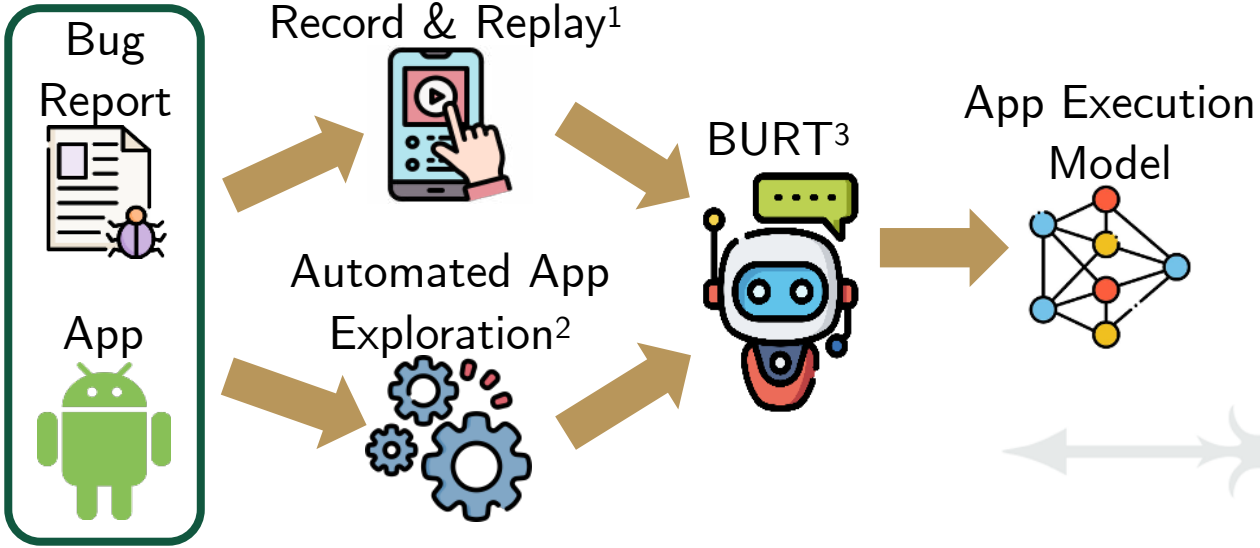

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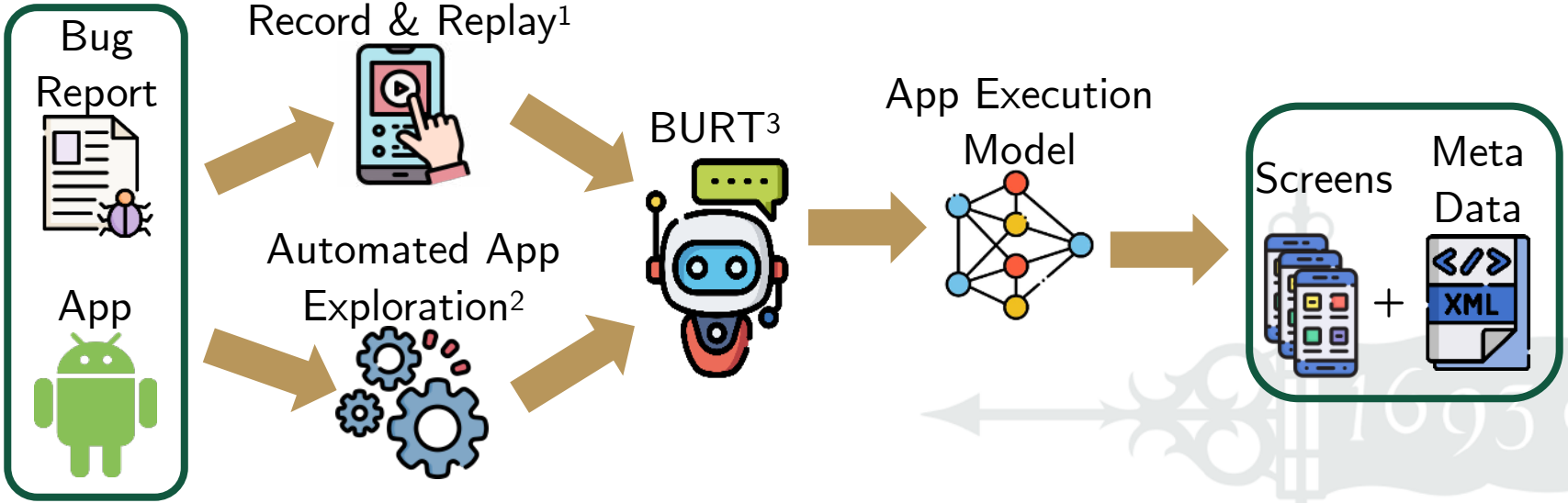

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Ground Truth Construction



Ground Truth Construction

For each OB, identify the buggy UI screens & components



Ground Truth Construction

For each OB, identify the buggy UI screens & components

4 Annotators



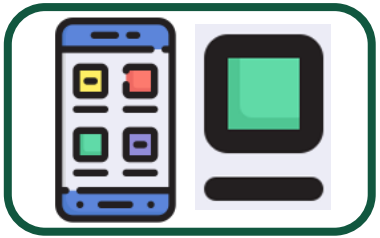
Ground Truth Construction

For each OB, identify the buggy UI screens & components

4 Annotators



Buggy UI Screen & Component



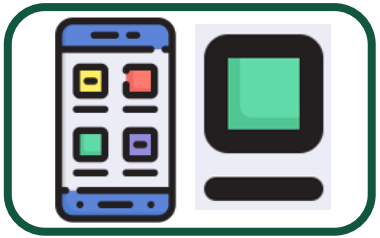
Ground Truth Construction

For each OB, identify the buggy UI screens & components

4 Annotators



Buggy UI Screen & Component



OB Quality Rating



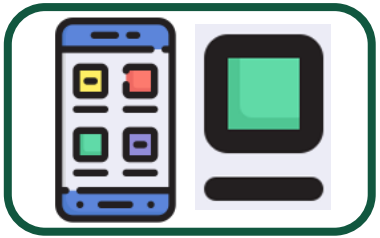
Ground Truth Construction

For each OB, identify the buggy UI screens & components

4 Annotators



Buggy UI Screen & Component



OB Quality Rating



Retrieval Difficulty Levels



EASY HARD

Screen Loc. (SL) Execution

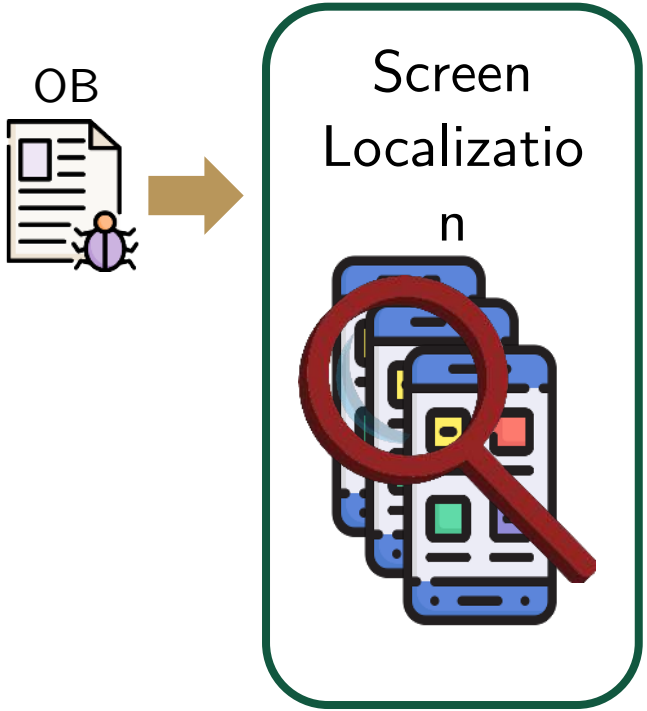


Screen Loc. (SL) Execution

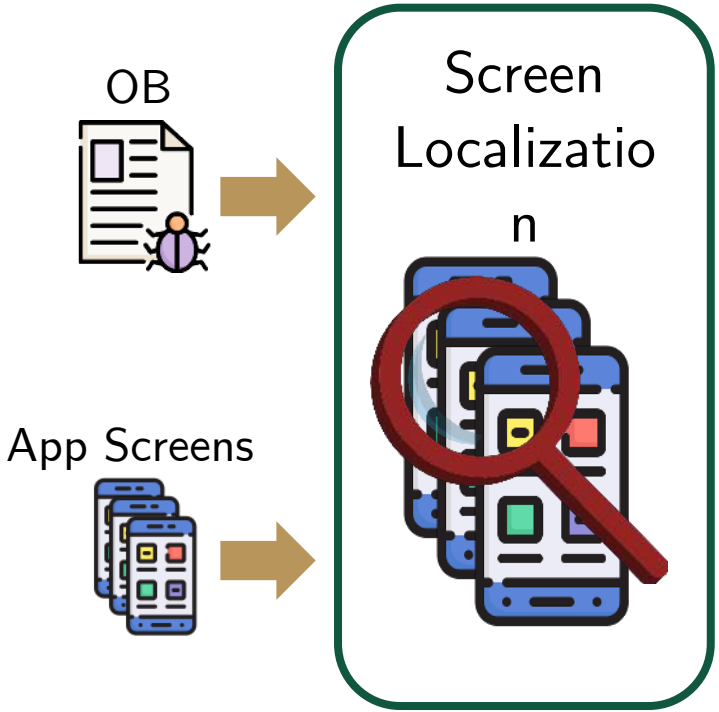
Screen Localizatio n



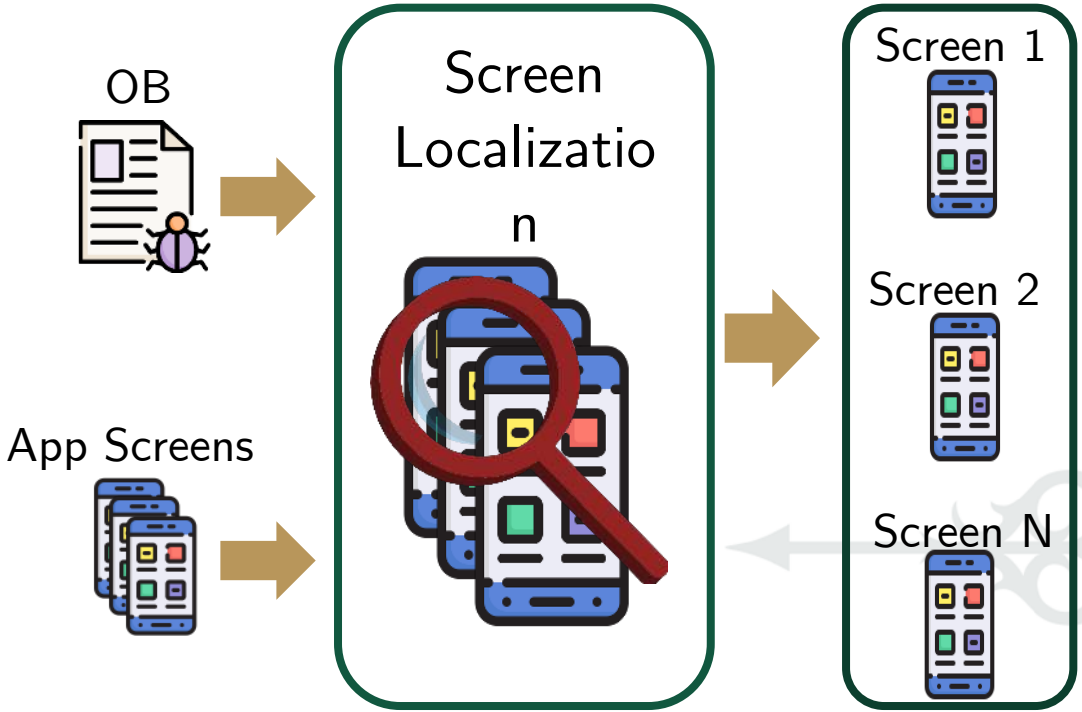
Screen Loc. (SL) Execution



Screen Loc. (SL) Execution



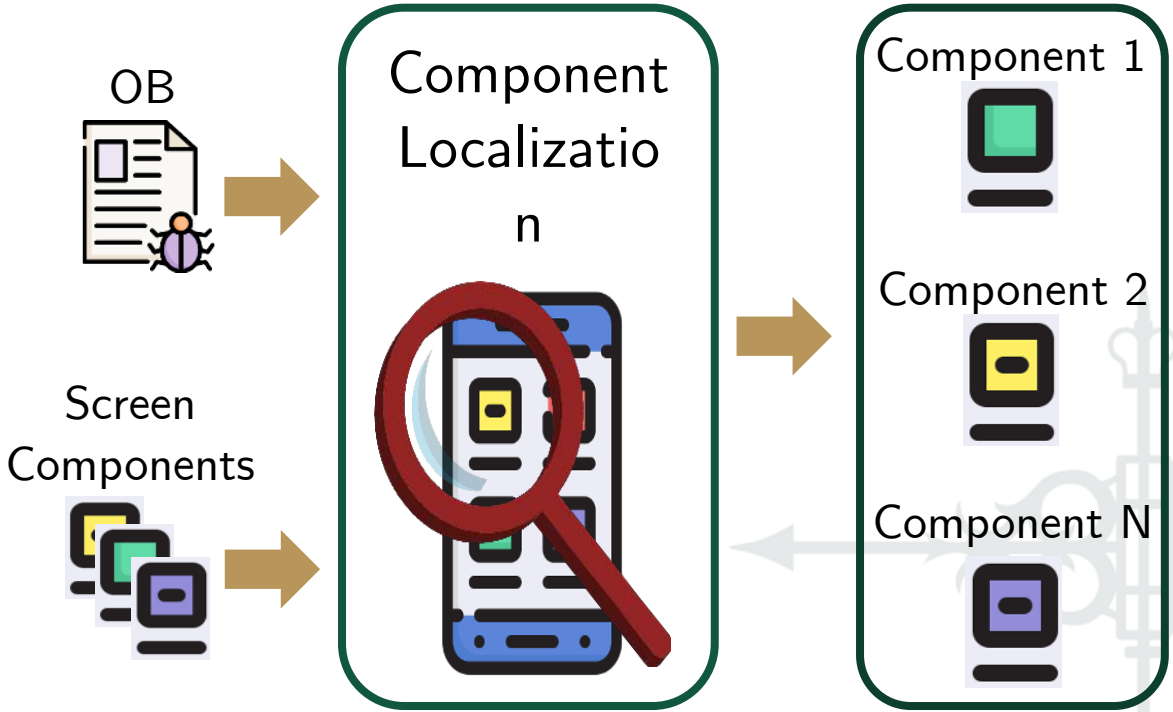
Screen Loc. (SL) Execution



Component Loc. (CL) Execution



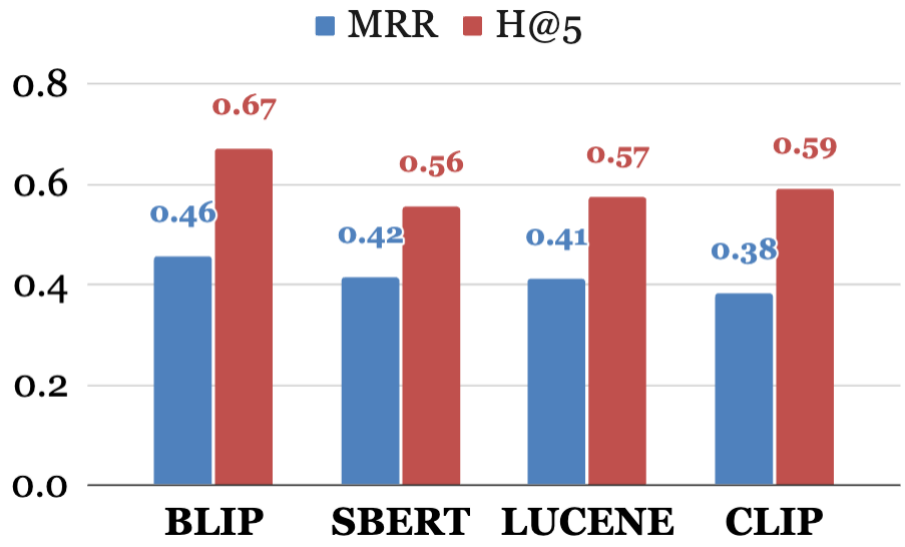
Component Loc. (CL) Execution



RQ1: Screen Localization (SL) Results



RQ1: Screen Localization (SL) Results



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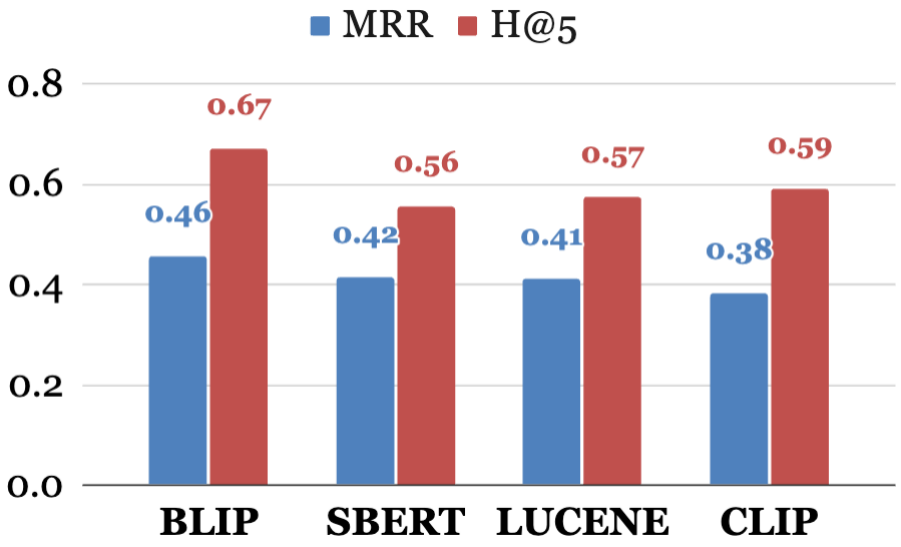
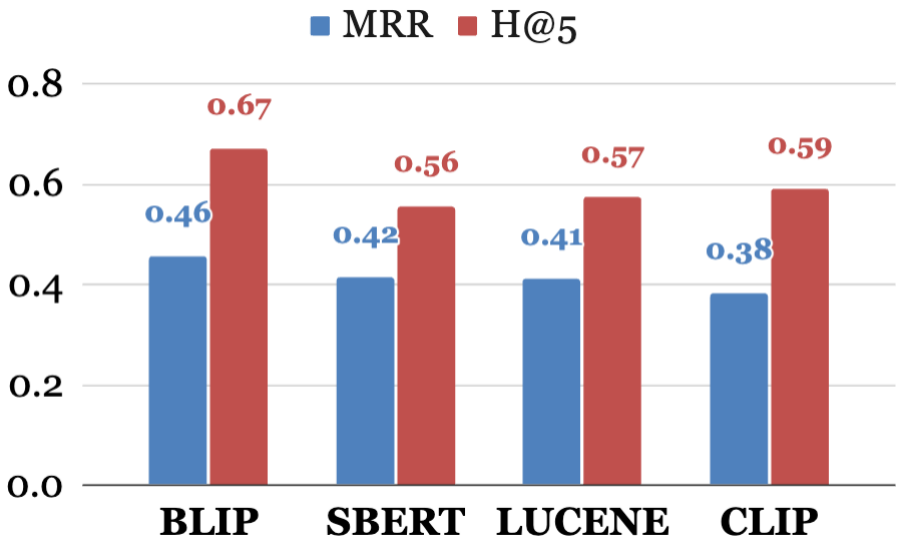


RQ1: Screen Localization (SL) Results

Best SL Model

BLIP



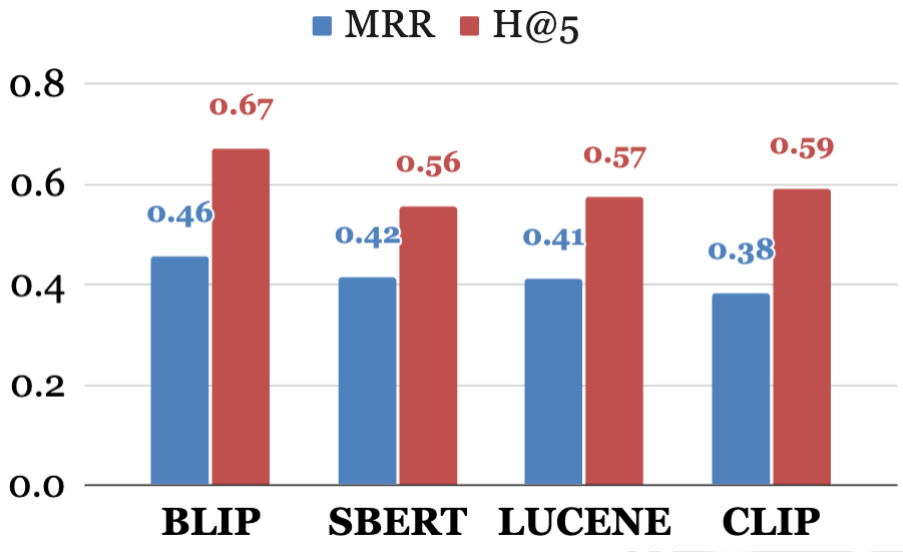
RQ1: Screen Localization (SL) Results

Best SL Model

BLIP

Outperforms SBERT

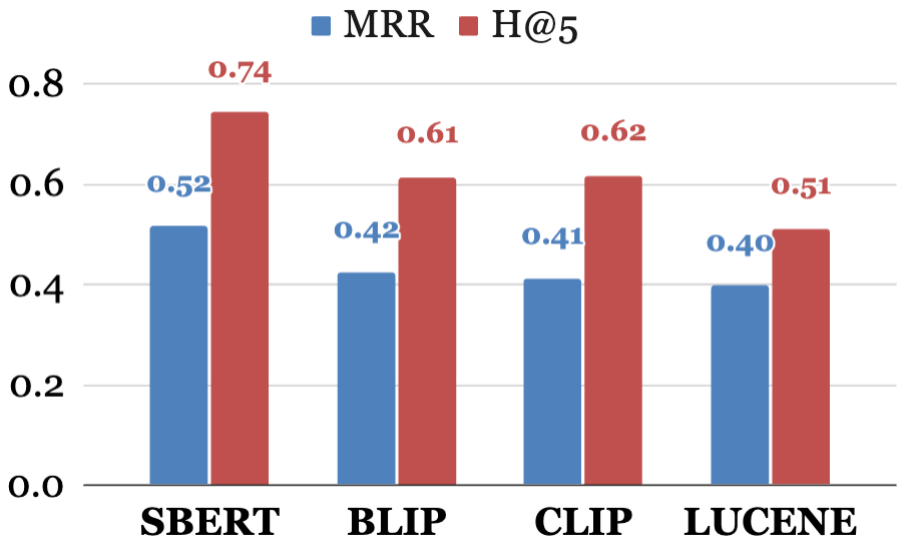
By 10.1% (MRR)
By 20.5% (H@5)



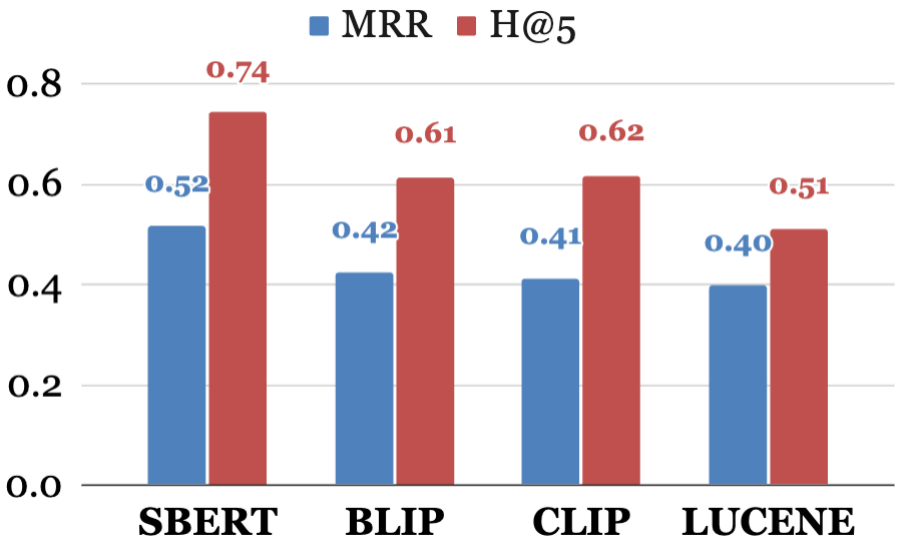
RQ2: Comp. Localization (CL) Results



RQ2: Comp. Localization (CL) Results



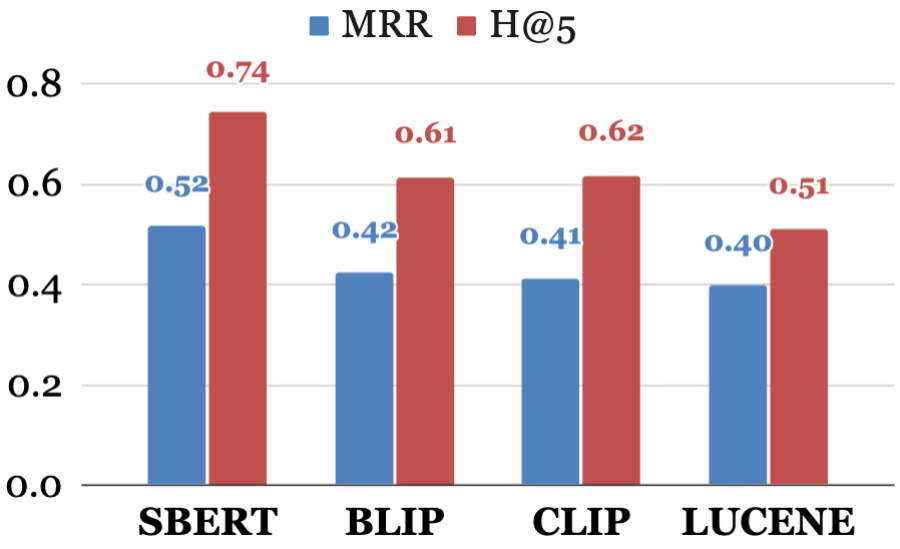
RQ2: Comp. Localization (CL) Results



RQ2: Comp. Localization (CL) Results

Best CL Model

SBERT



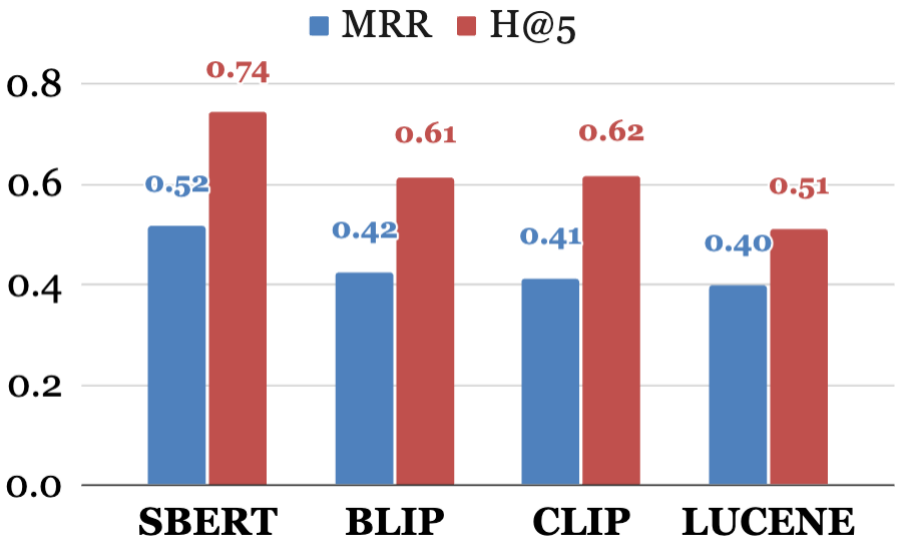
RQ2: Comp. Localization (CL) Results

Best CL Model

SBERT

Outperforms BLIP

By 21.9% (MRR)
By 21.2% (H@5)



RQ3: Query Quality vs. Results



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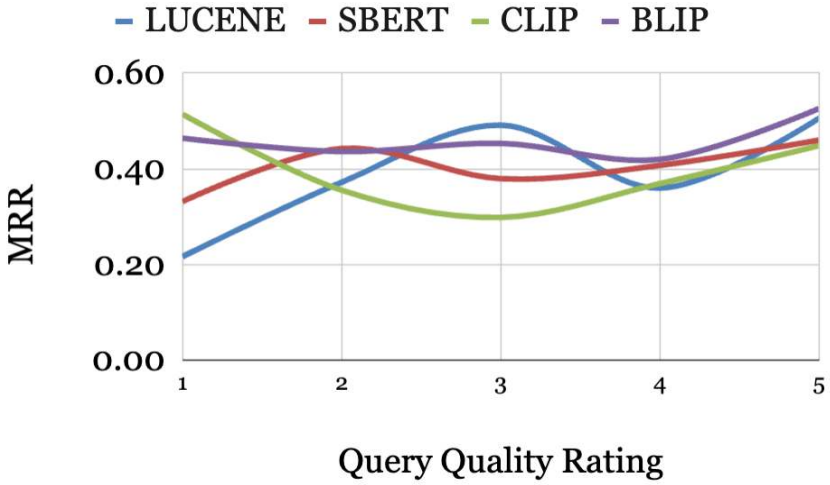

SL

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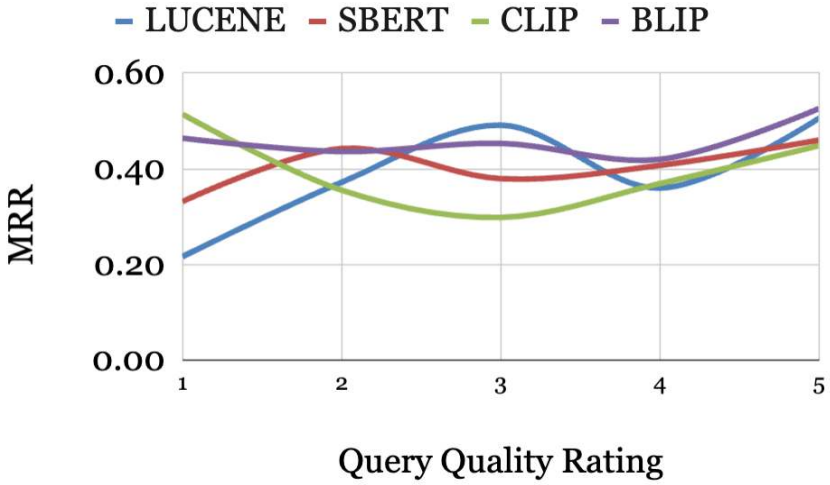

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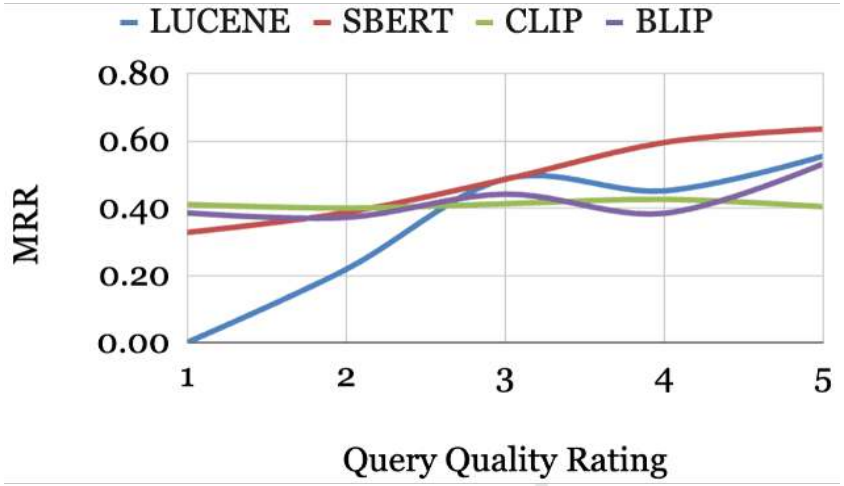

CL

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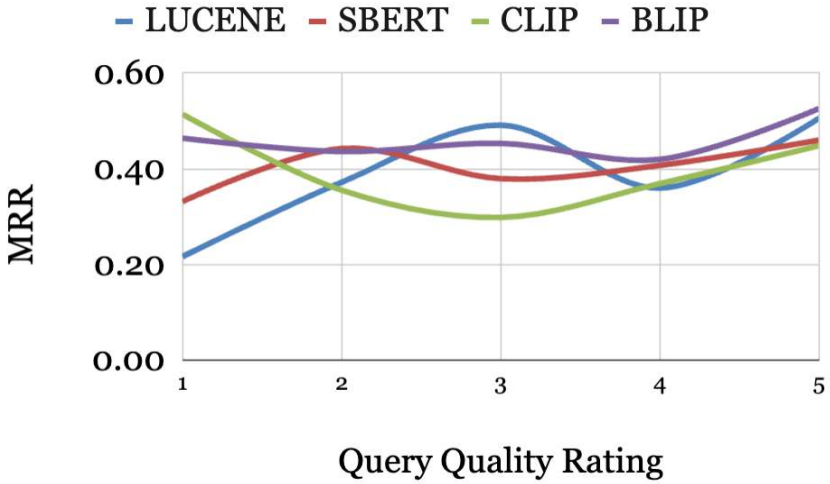

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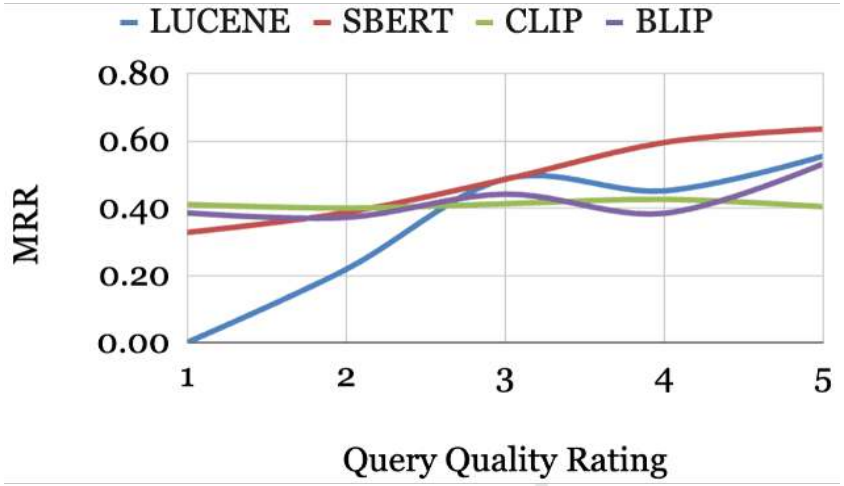


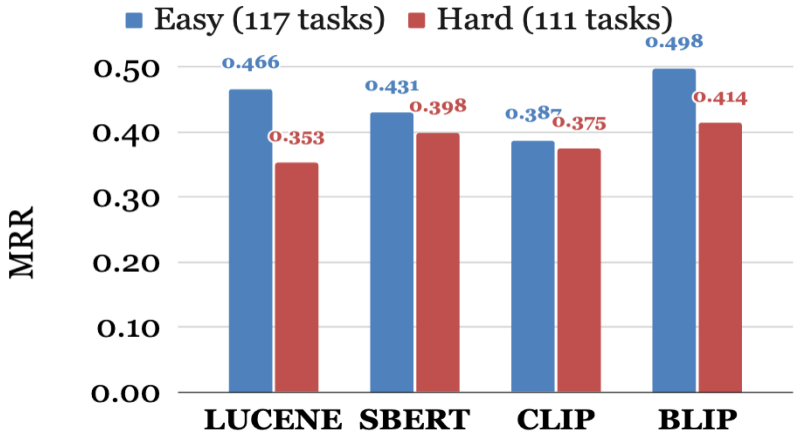
CL

All models perform best for the most informative queries (rating =

RQ3: Retrieval Difficulty vs. SL Results

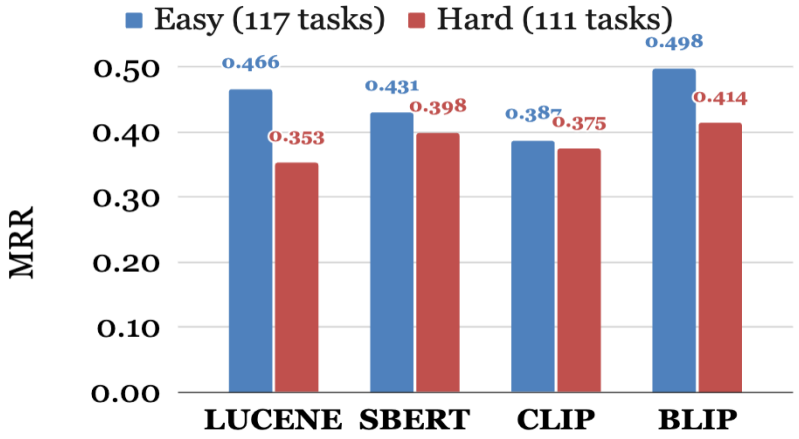


RQ3: Retrieval Difficulty vs. SL Results



SL

RQ3: Retrieval Difficulty vs. SL Results



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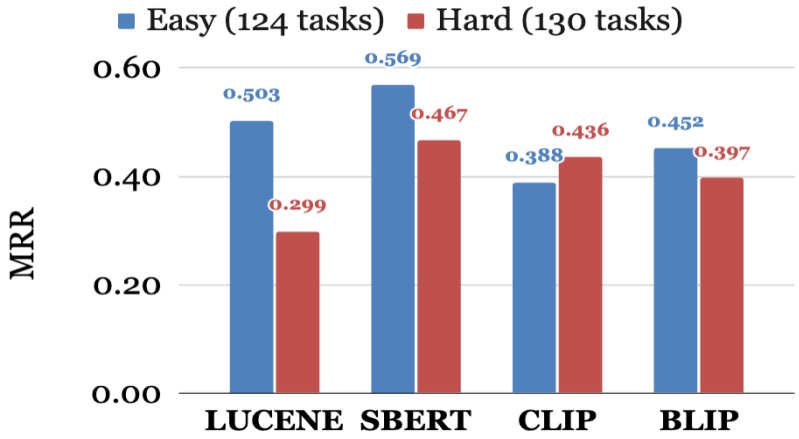
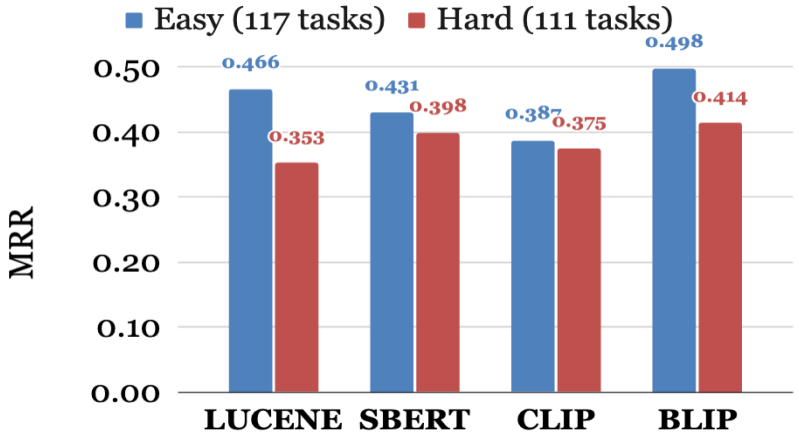


CL

RQ3: Retrieval Difficulty vs. SL Results



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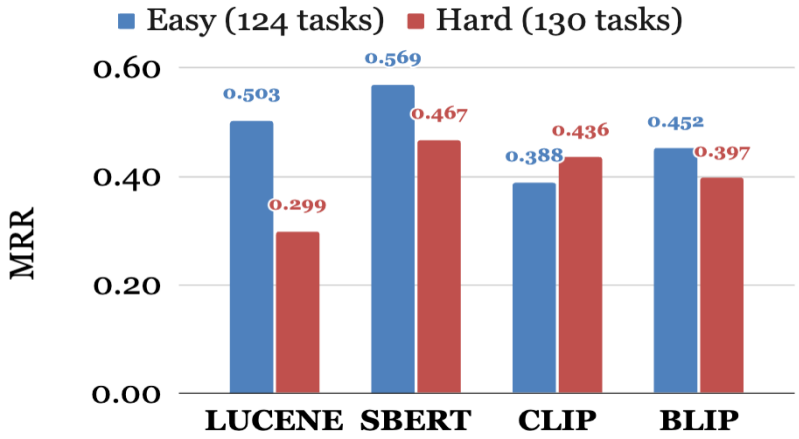


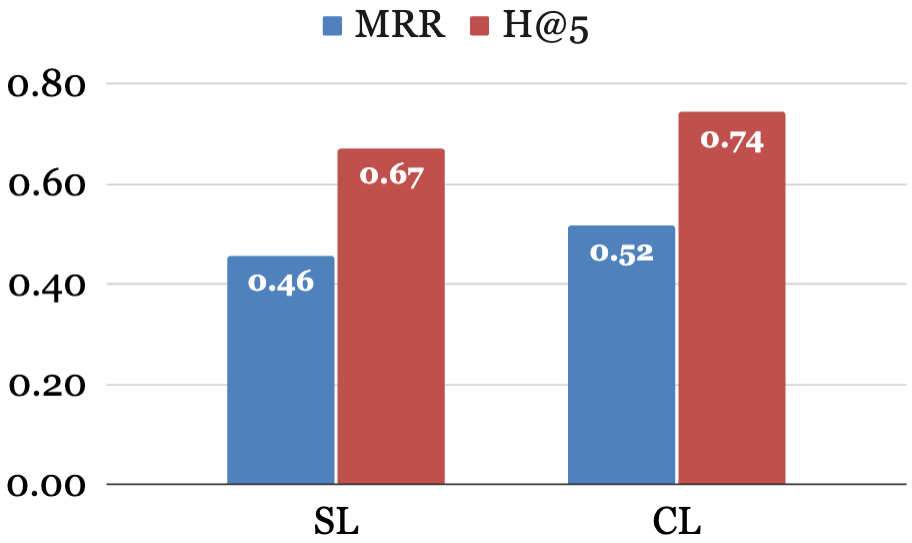
CL

All models perform higher on easy-to-retrieve tasks

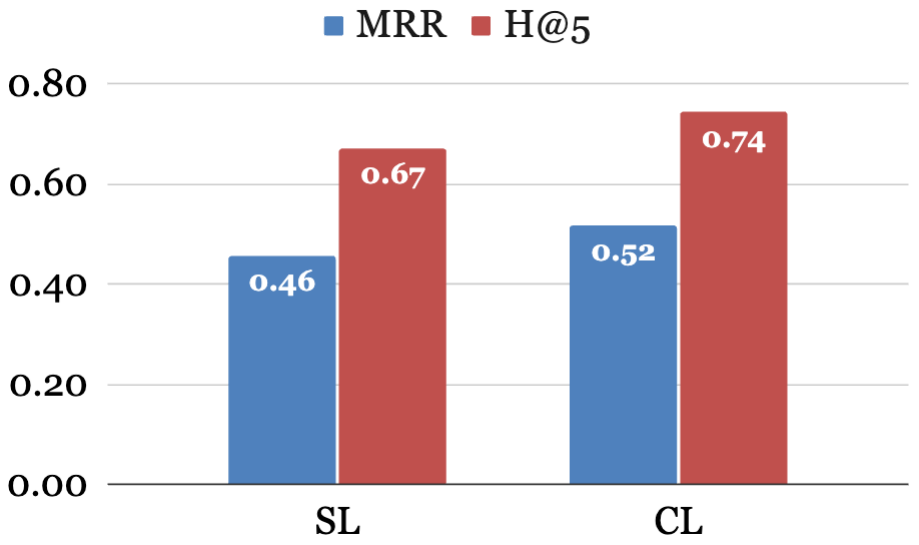
Screen vs. Component Localization



Screen vs. Component Localization

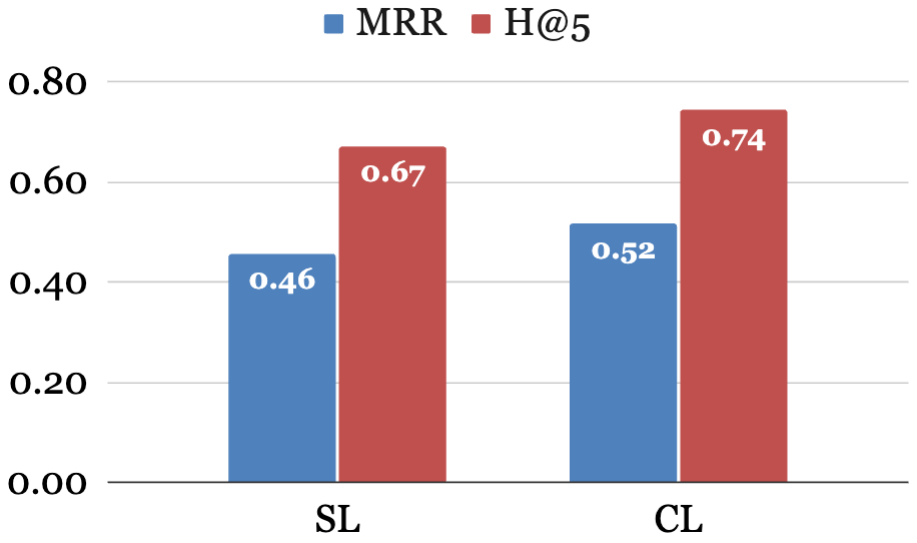


Screen vs. Component Localization



Screen vs. Component Localization

SL is more challenging

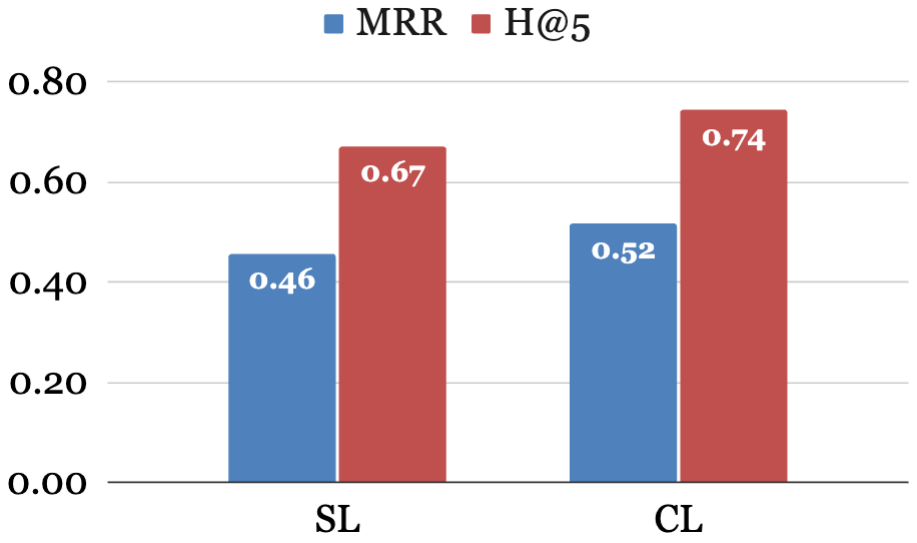


Screen vs. Component Localization

SL is more challenging

Corpus Size

26 per App vs.
17 per Screen



Screen vs. Component Localization

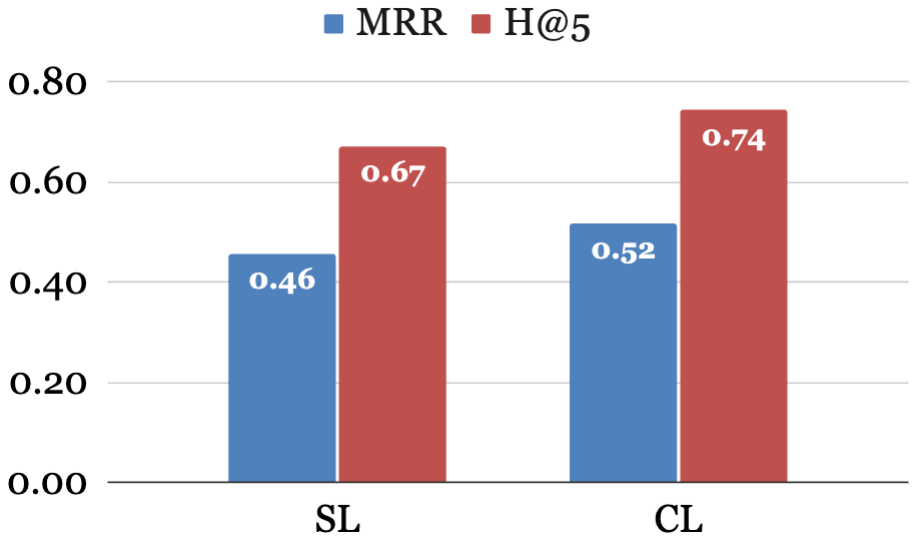
SL is more challenging

Corpus Size

26 per App vs.
17 per Screen

Scope of SL is Broader

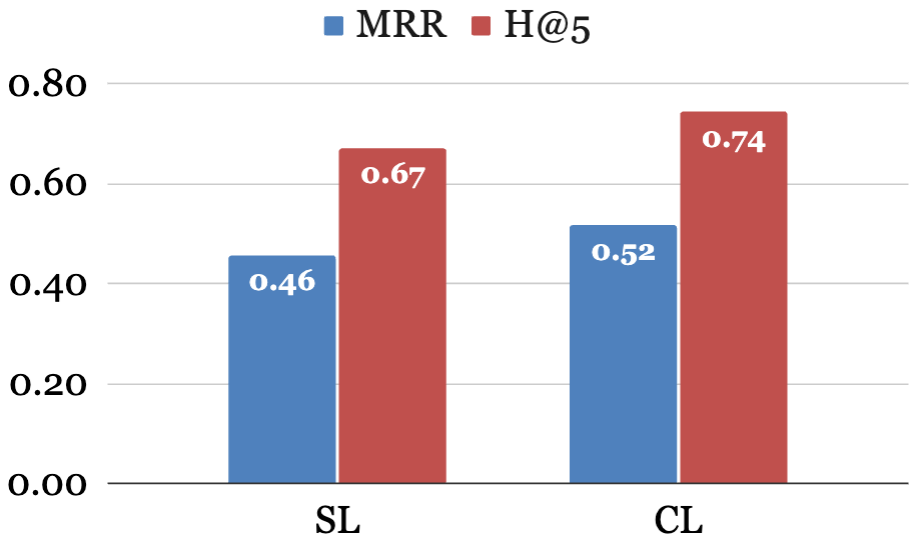
All Screens of App vs.
All comp. of a Screen



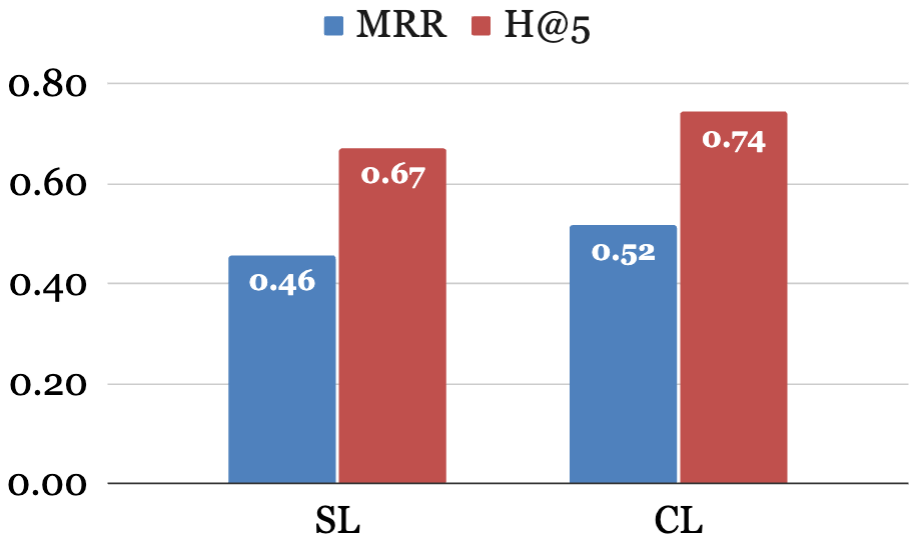
Textual vs. Multi-modal Models



Textual vs. Multi-modal Models

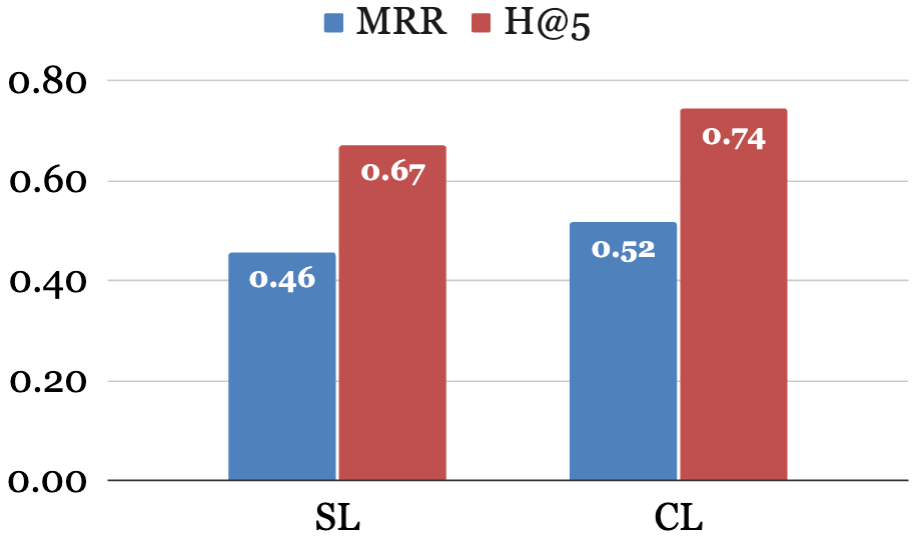


Textual vs. Multi-modal Models



BLIP

Textual vs. Multi-modal Models



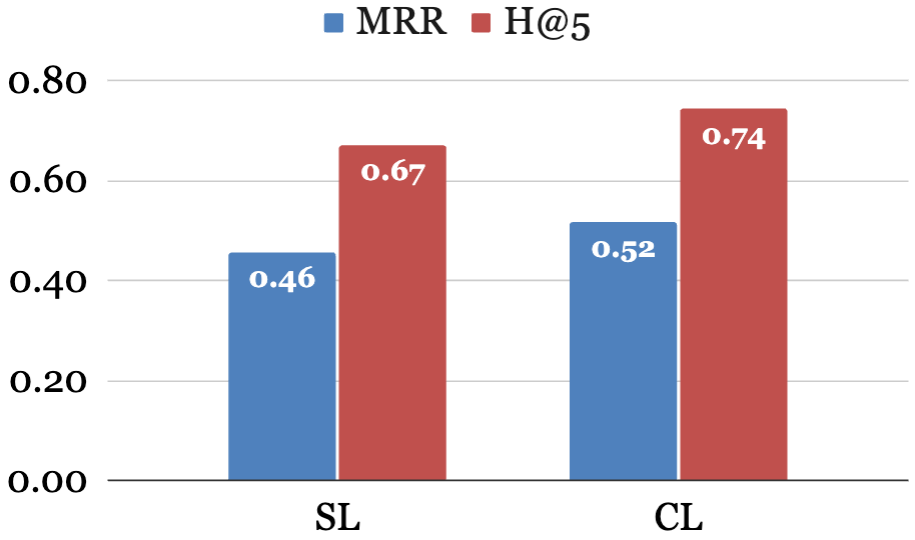
BLIP

SBERT

Textual vs. Multi-modal Models

SL: Multi-Modal Model

Model should understand full context of the screen



BLIP

SBERT

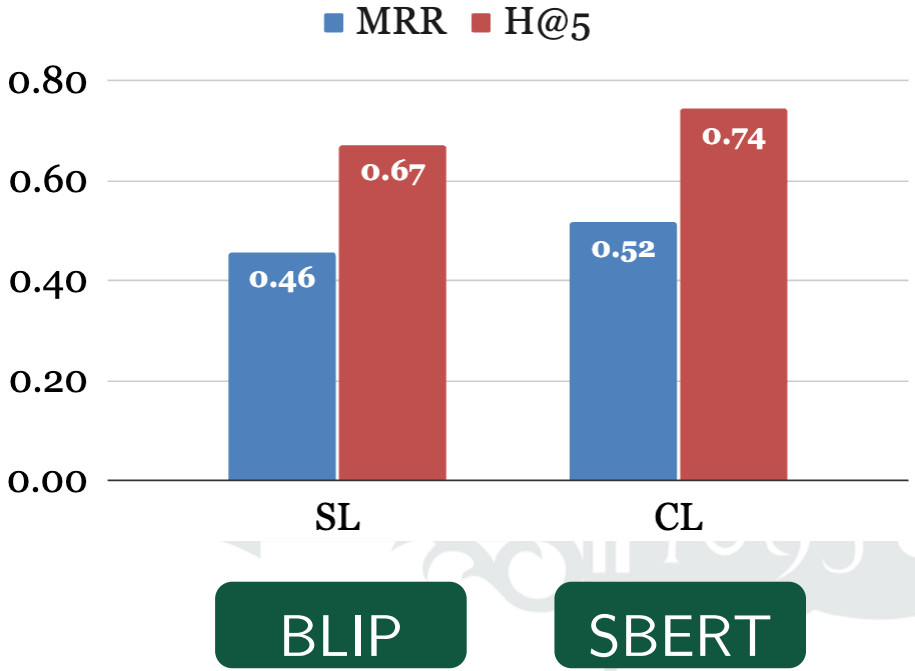
Textual vs. Multi-modal Models

SL: Multi-Modal Model

Model should understand full context of the screen

CL: Textual Model

OBs are written using component text

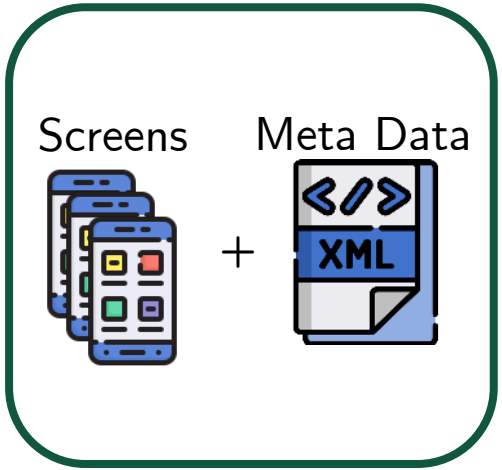


Enhanced Buggy UI Localization



Enhanced Buggy UI Localization

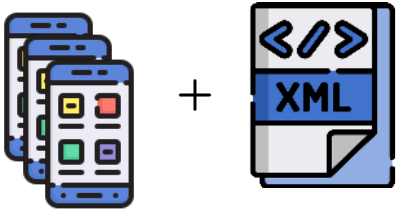
Both Visual & Textual Information



Enhanced Buggy UI Localization

Both Visual & Textual Information

Screens + Meta Data



Distinct Models for Screen & Component Localization

Screen Localizatio



Component Localizatio



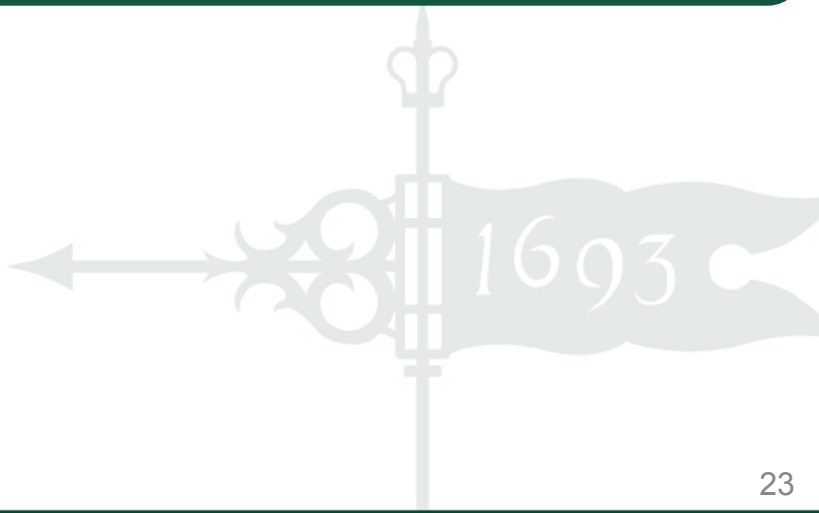
Usefulness of Buggy UI Localization



Usefulness of Buggy UI Localization

Goal

Apply Buggy UI Localization to automate IR-Based Buggy Code Localization



Usefulness of Buggy UI Localization

Goal

Apply Buggy UI Localization to automate IR-Based Buggy Code Localization

RQs

4. Can the identified buggy UI screens by BLIP lead to improved buggy code localization?

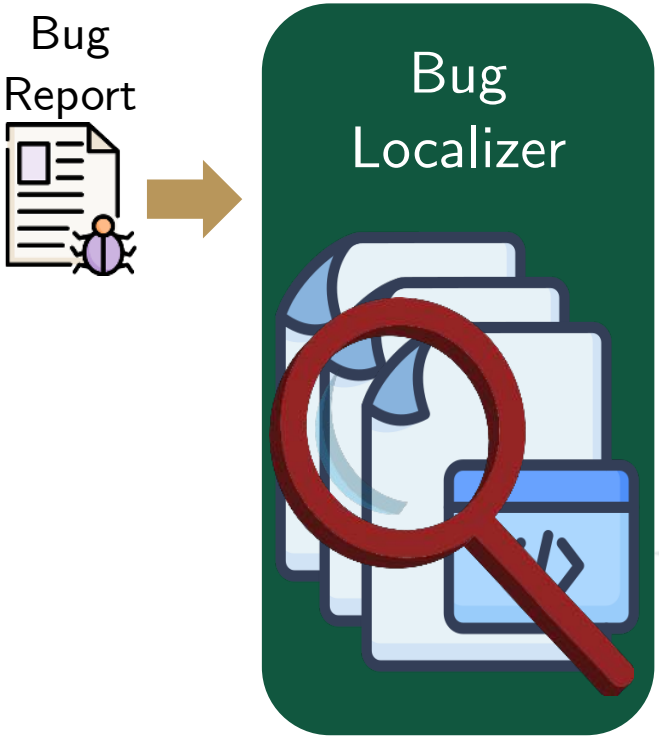
Buggy Code Localization



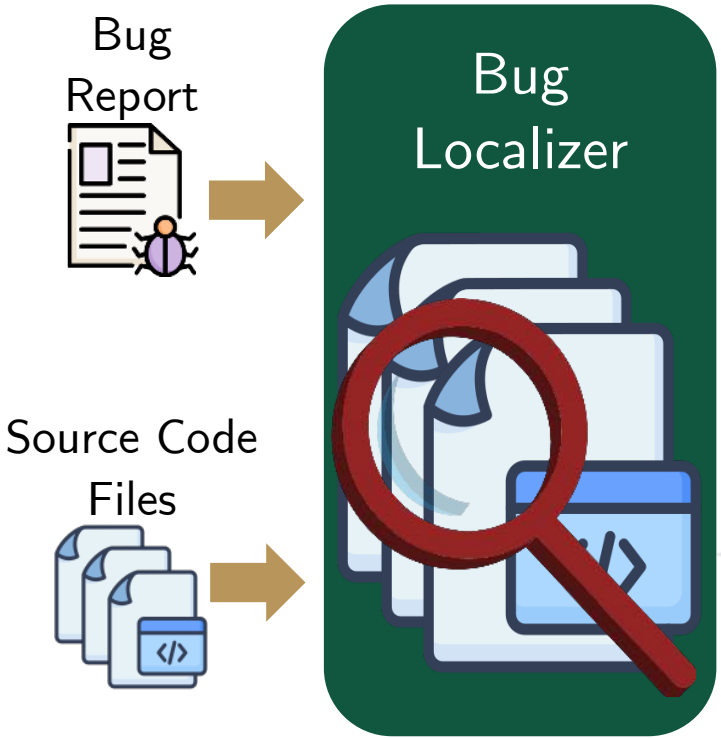
Buggy Code Localization



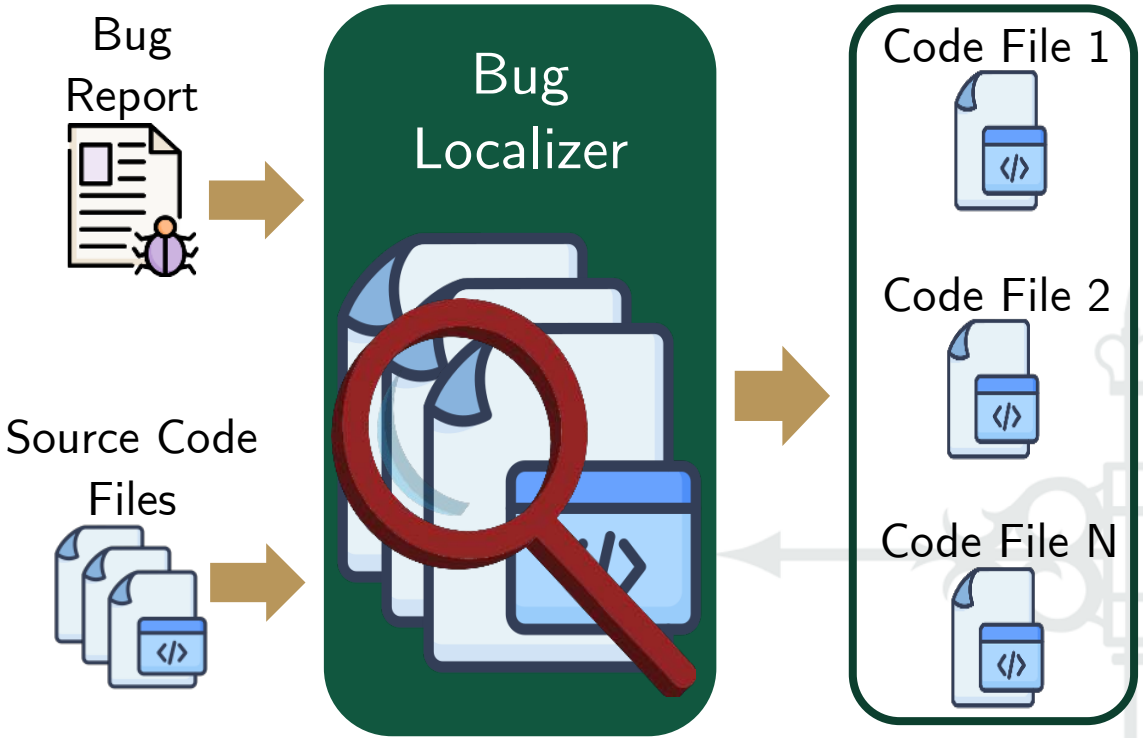
Buggy Code Localization



Buggy Code Localization



Buggy Code Localization

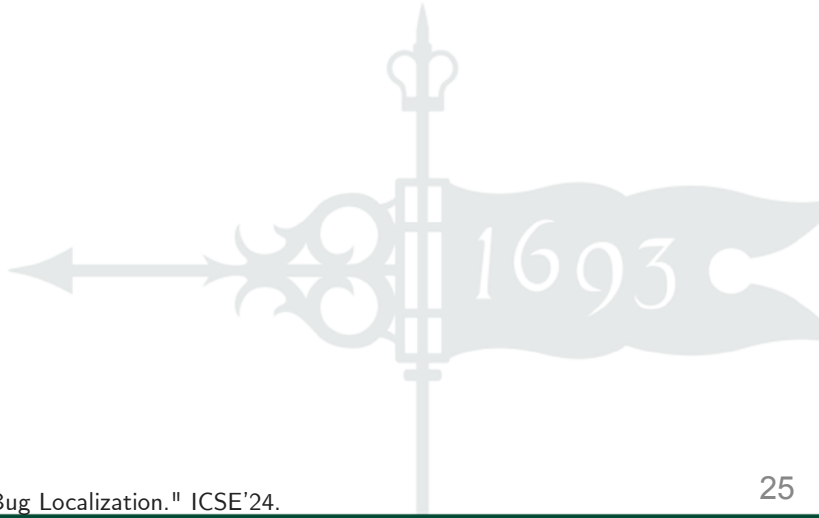


Integrating Buggy UI and Code Localization



Integrating Buggy UI and Code Localization

UI interaction data can improve IR-based buggy code localizers[1]



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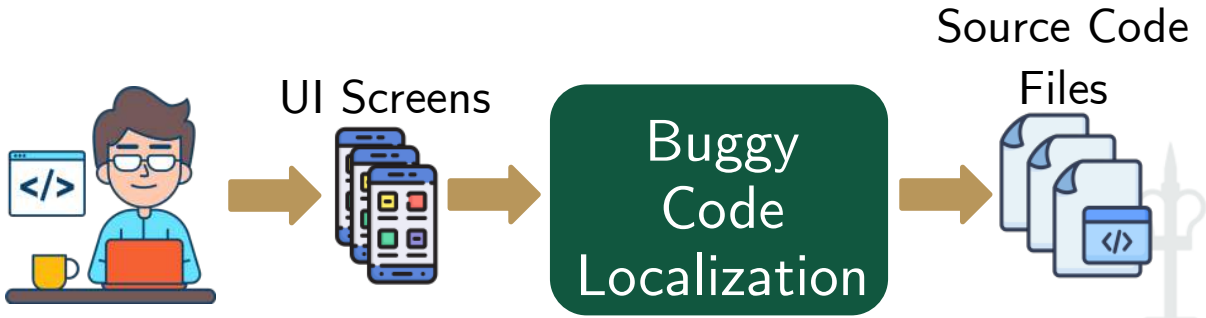

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Integrating Buggy UI and Code Localization

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Our goal is to eliminate the manual effort of developers

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Integrating Buggy UI & Code Loc.



Integrating Buggy UI & Code Loc.

End-to-End Automated Approach



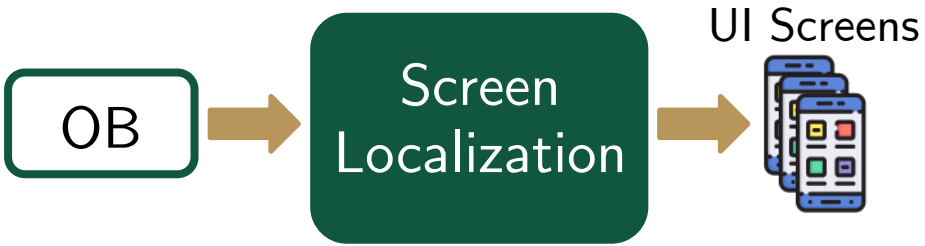
Integrating Buggy UI & Code Loc.

End-to-End Automated Approach



Integrating Buggy UI & Code Loc.

End-to-End Automated Approach



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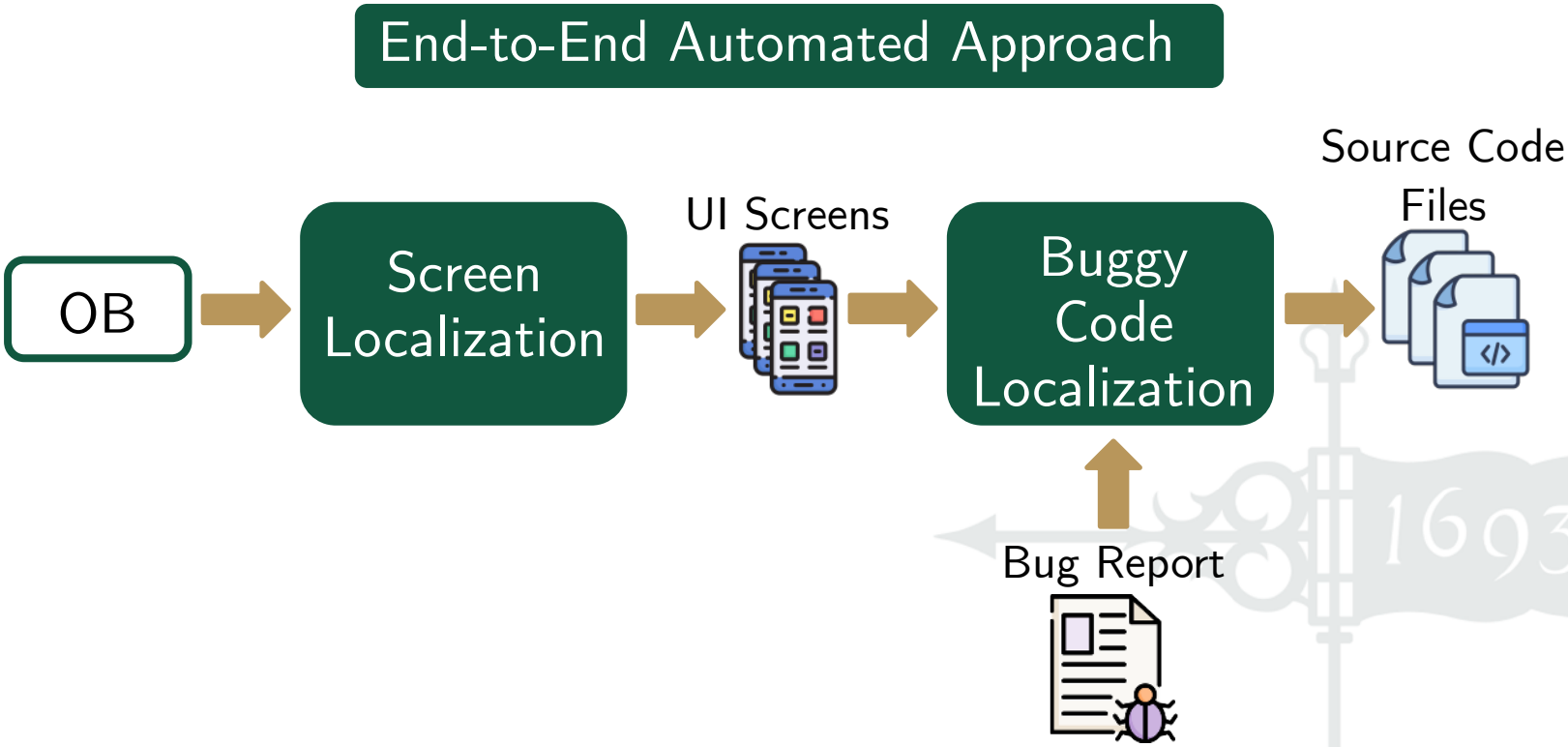

Integrating Buggy UI and Code Localization



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Challenge: One bug report can have multiple OB descriptions



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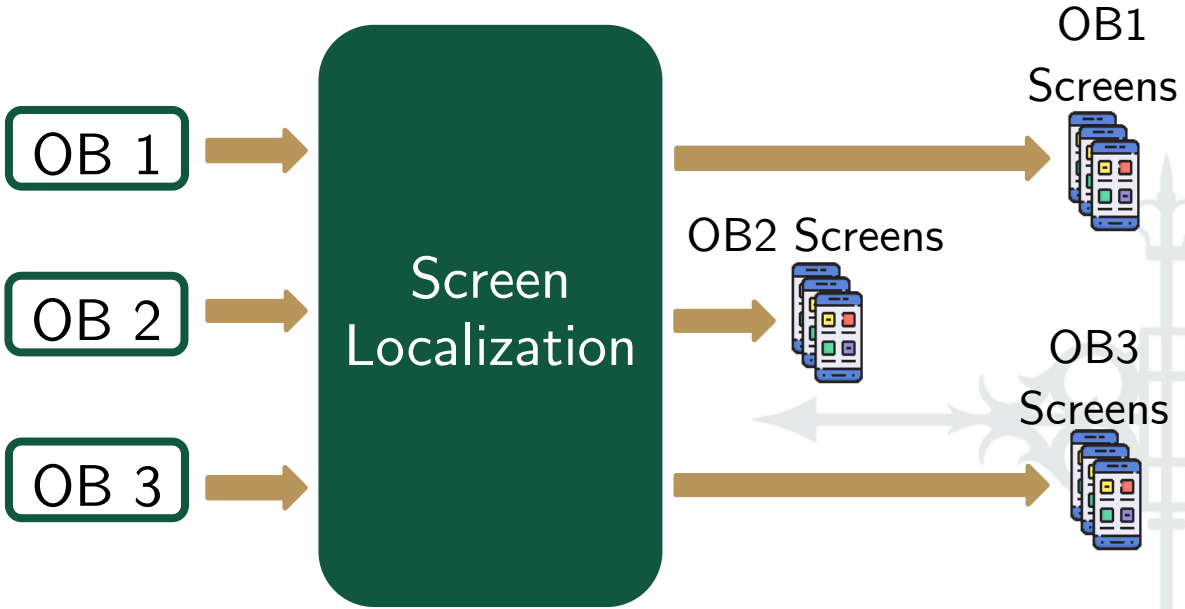

Integrating Buggy UI and Code Localization



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Which set of screens should be used for Buggy Code Localization?



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Pipeline#1

ConcatOB

OB 1
+
OB 2
+
OB 3

Integrating Buggy UI and Code Localization

Which set of screens should be used for Buggy Code Localization?

Pipeline#1

ConcatOB

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OB 2
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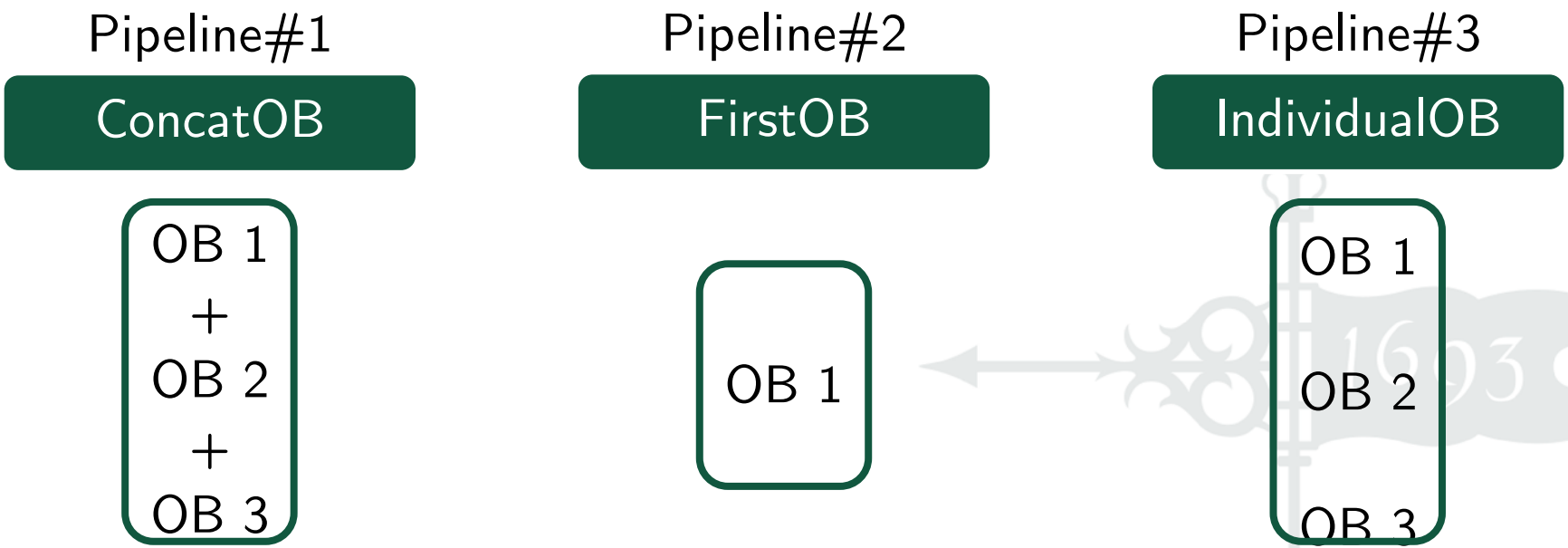
Pipeline#2

FirstOB

OB 1

Integrating Buggy UI and Code Localization

Which set of screens should be used for Buggy Code Localization?



Buggy Code Localization Execution



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Buggy UI Localization Pipelines

ConcatOB | TitleOB | IndividualO

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Approaches

LUCENE[1] | BugLocator[2]

1 Gospodnetic, Otis, Erik Hatcher, and Michael McCandless. Lucene in action. Simon and Schuster, 2010.

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Buggy Code Localization Execution

Buggy UI Localization Pipelines: ConcatOB | TitleOB | IndividualO

Approaches: LUCENE[1] | BugLocator[2]

Evaluation Dataset: 79 Bug Reports from Mahmud et al.[3]

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2 Zhou, Jian, et al. "Where should the bugs be fixed? more accurate information retrieval-based bug localization based on bug reports." ICSE'12.

3 Mahmud, Junayed, et al. "On Using GUI Interaction Data to Improve Text Retrieval-based Bug Localization." ICSE 24.

RQ4: Buggy Code Localization Results



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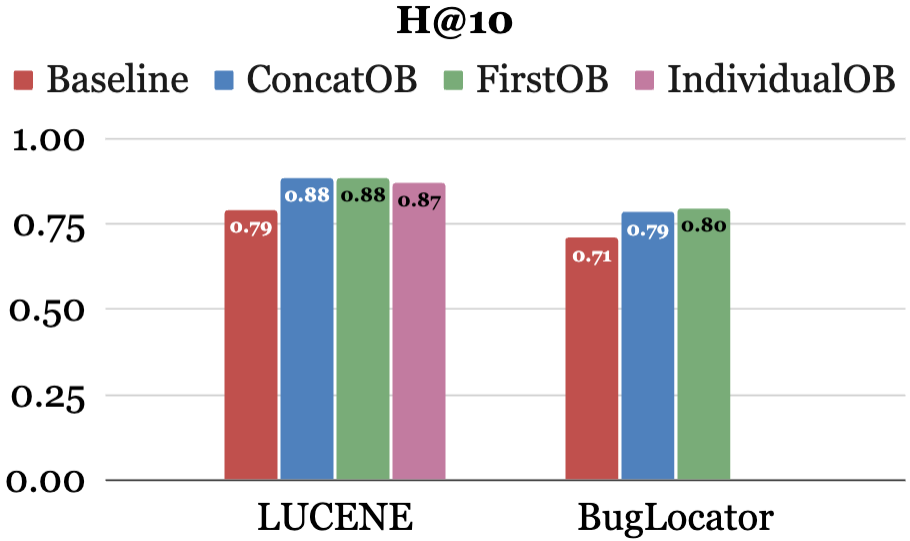

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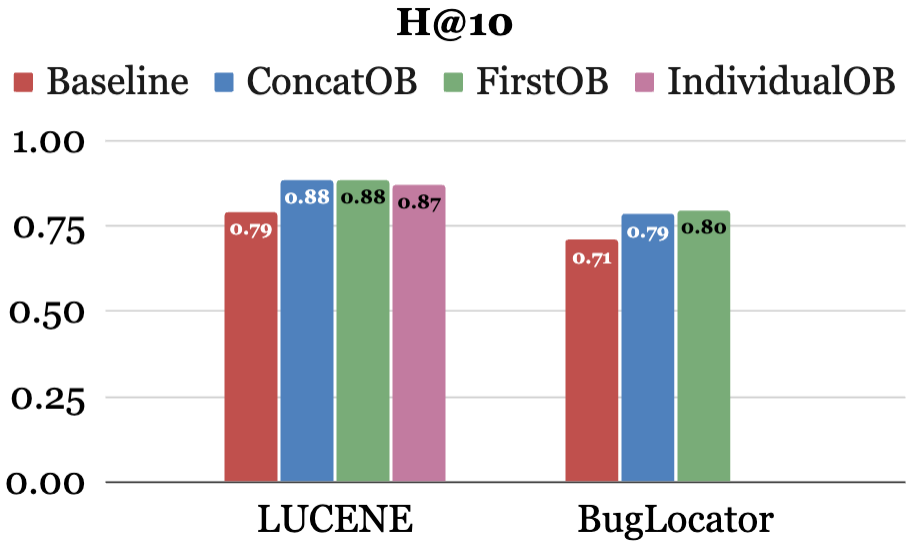
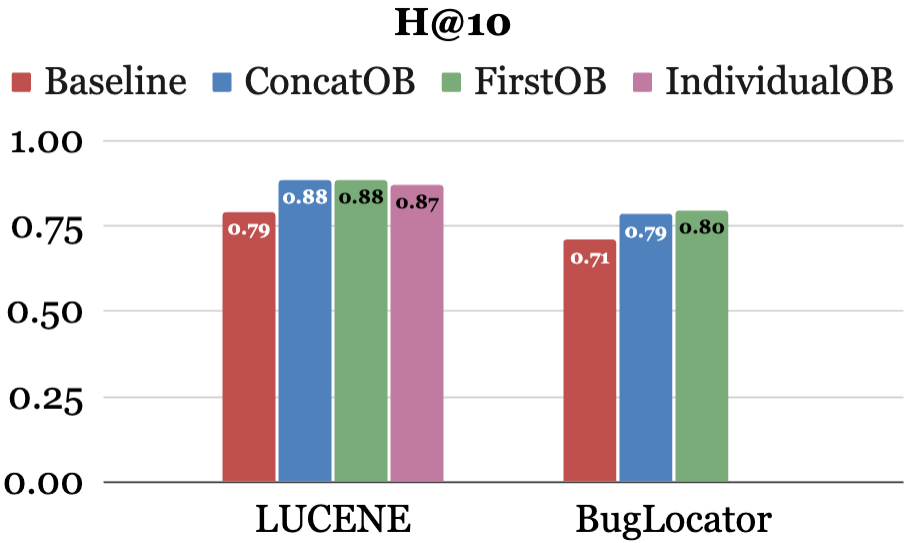


RQ4: Buggy Code Localization Results

Best Pipelines

LUCENE: ConcatOB & FirstOB
BugLocator: FirstOB



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Outperforms Baselines

LUCENE: By 11.49% (H@10)
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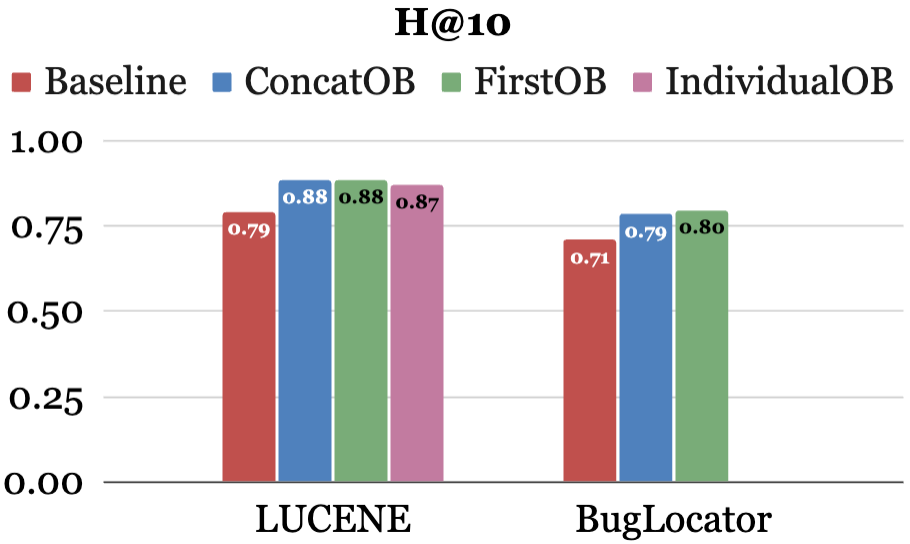

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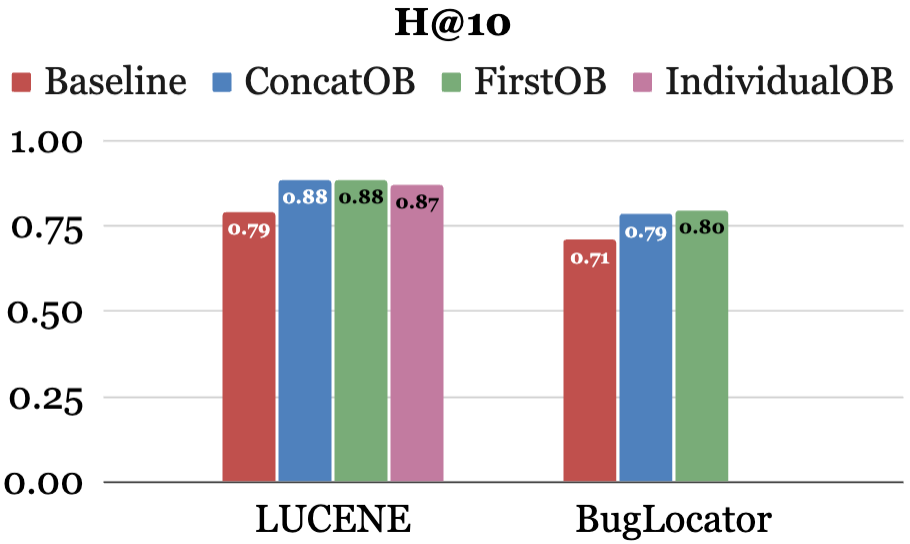


Buggy UI Localization can automate & improve UI-based Buggy Code Localization

Summary



Summary

Buggy UI Localizatio n (S CL)



Summary

Buggy UI Localization (S[illegible] CL)



Constructed a Novel Dataset



Summary

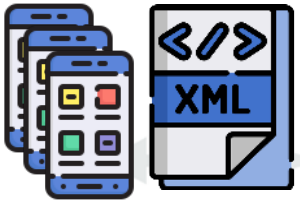
Buggy UI Localizatio n (S… CL)



Constructe d a Novel Dataset



Investigate d Information Sources



Summary

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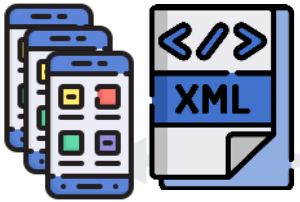
Constructed a Novel Dataset



Investigated Information Sources



Bug Localization Using SL

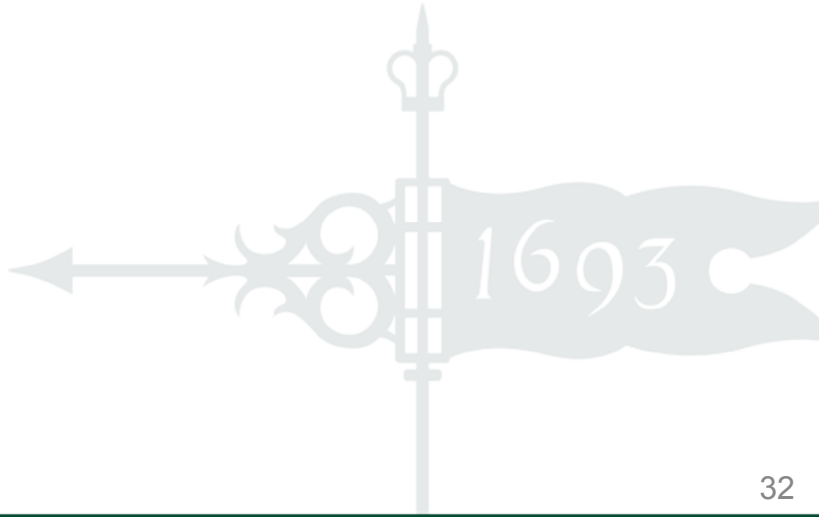


Take Aways



Take Aways

Existing DL approaches can be used for Buggy UI Localization tasks (SL & CL)



Take Aways

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Both visual & textual sources of information are effective for Buggy UI Localization

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Both visual & textual sources of information are effective for Buggy UI Localization

Buggy UI Localization can automate & improve Bug Localization



SCAN ME

Let's get connected!

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asaha02@wm.edu