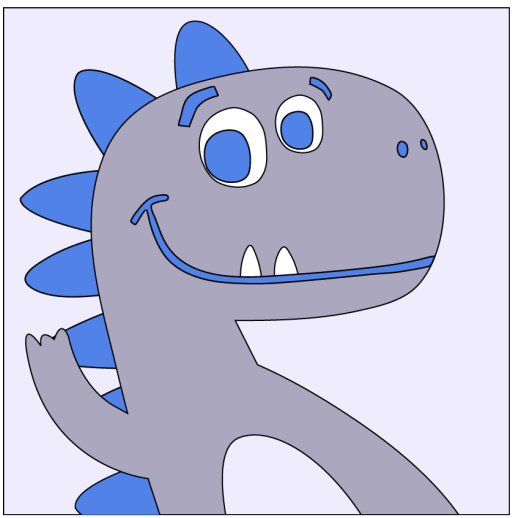
TIREx: The Information Retrieval Experiment Platform

Towards Reproducible Shared Tasks in IR



SIGIR 2023, July 23–27, Taipei, Taiwan

Maik Fröbe, Jan Heinrich Reimer, Sean MacAvaney, Niklas Deckers, Simon Reich, Janek Bevendorff, Benno Stein, Matthias Hagen, and Martin Potthast

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TIREx: The Information Retrieval Experiment Platform

Motivation: SIGIR ’20 Keynote by Norbert Fuhr

Solid Empirical Evidence is Important!

Norbert Fuhr Proof by Experimentation? Towards Better IR Research 7

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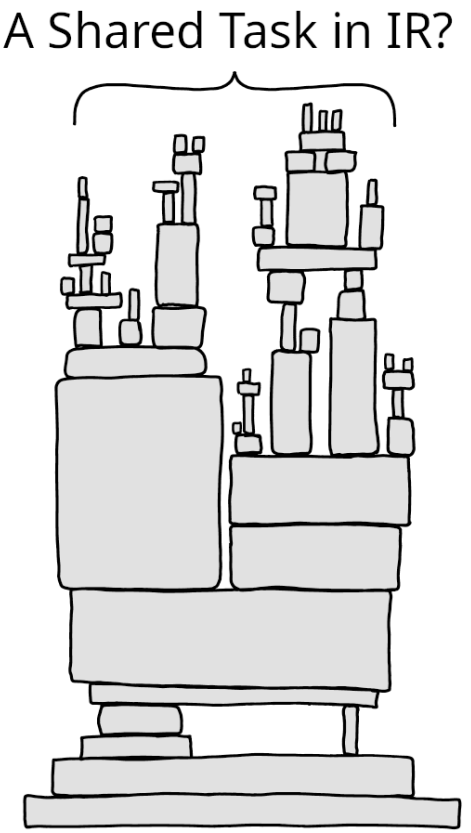

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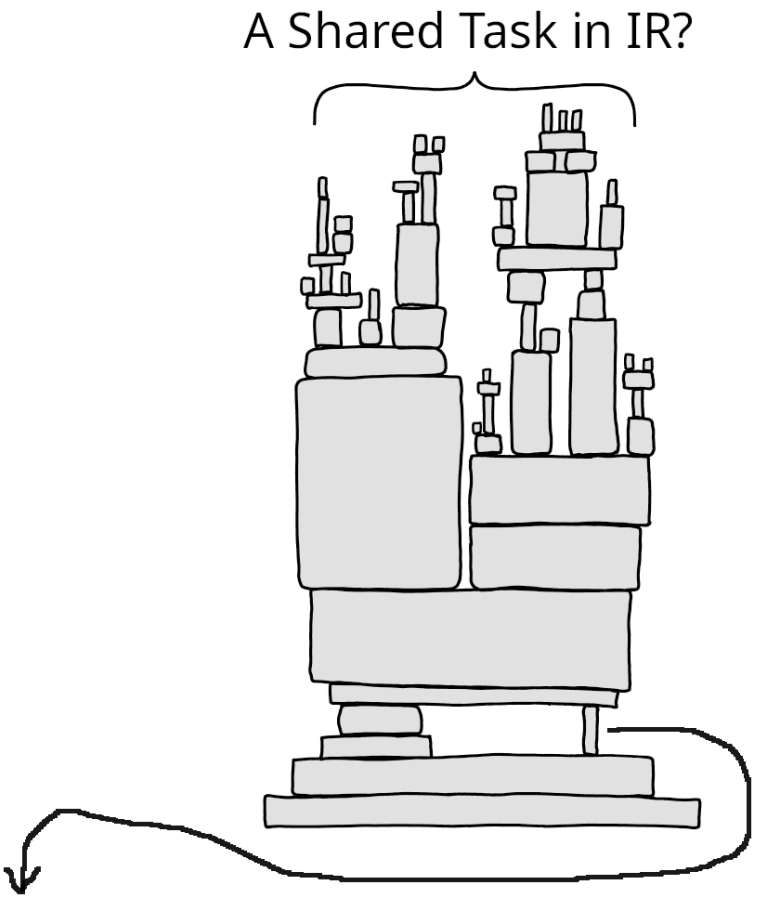

Potential problems:
[Fuhr'21]

- Problem 1: Internal validity
- Problem 2: External validity

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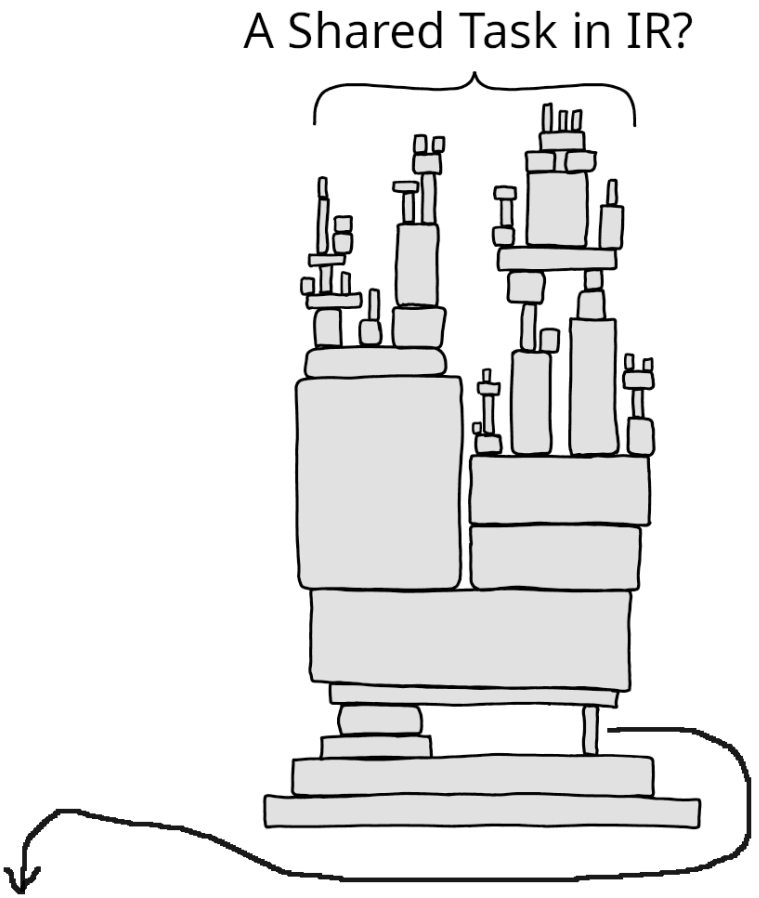

Potential problems:
[Fuhr'21]

- Problem 1: Internal validity
- Problem 2: External validity
- Problem 3: Blinded experimentation with LLMs

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Problem 1: Internal Validity [Fuhr'21]

Goal

The hypothesis is supported by the data.

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- Wrong baseline
  [Armstrong'09,Lin'18]
- Formulate hypothesis after experiments
  [Fuhr'21]

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Possible solutions

- Centralized leaderboards
  - E.g., Run uploads to EvaluateIR
    [Armstrong'09]
- Task-specific leaderboards
  - E.g., MS MARCO, MIRACL
    [Lin'22,Zhang'22]

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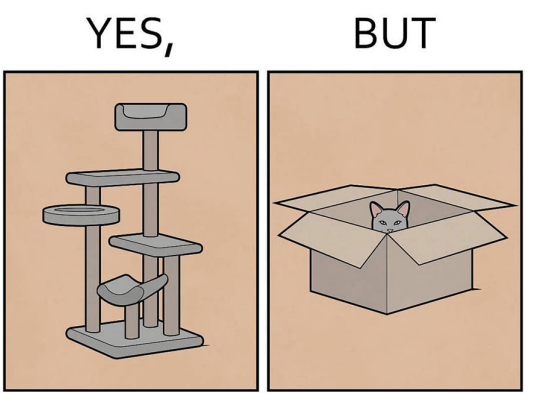

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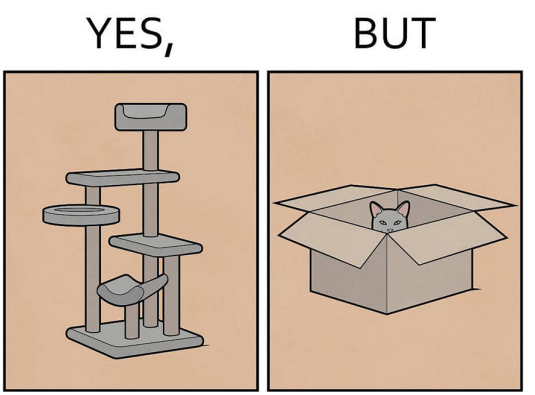

"EvaluateIR never gained traction, and a number of similar efforts following it have also floundered"
[Lin'18]

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Problem 2: External Validity [Fuhr'21]

Goal

Repeating an experiment on similar data yields similar observations.

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Possible problems

- Non-reproducible results

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Problem 2: External Validity [Fuhr'21]

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Possible Solutions

- TREC Open Runs
  [Voorhees'16]
- Reproducibility initiatives
  - OSIRRC: Archive artifacts
    [Arguello'15,Clancy'19]
  - CENTRE: Reimplementation
    [Ferro'19,Sakai'19]
- Platforms + documentation
  - CodaLab, EvalAI, PRIMAD, STELLA, TIRA
- Meta evaluations: BEIR
  [Thakur'21]

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Problem 2: External Validity [Fuhr'21]

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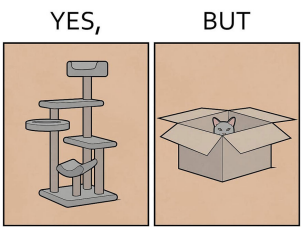

Possible problems

- Non-reproducible results

Possible Solutions

- TREC Open Runs [Voorhees'16]
  - 19 of 69 runs (Problems: 11)
- Reproducibility initiatives
  - OSIRRC: Archive artifacts [Arguello'15,Clancy'19]
    - 2015: 8 systems archived
    - 2019: 1 system fully reproducible [Lin'19]
  - CENTRE: Reimplementation [Ferro'19,Sakai'19]
    - Limited adoption of jig + CIFF [Clancy'19]
- Platforms + documentation
  - CodaLab, EvalAI, PRIMAD, STELLA, TIRA
    - Additional effort
- Meta evaluations: BEIR [Thakur'21]
  - Evaluations on subsets
  - Often sparse judgments

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Problem 3: Blinded Experimentation with LLMs

Percy Liang
@percyliang

I worry about language models being trained on test sets. Recently, we emailed support@openai.com to opt out of having our (test) data be used to improve models. This isn't enough though: others running evals could still inadvertently contribute those test sets to training.

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Problem 3: Blinded Experimentation with LLMs

Percy Liang
@percyliang

I worry about language mo
emailed support@openai.
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could still inadvertently co

Horace He
@cHHillee

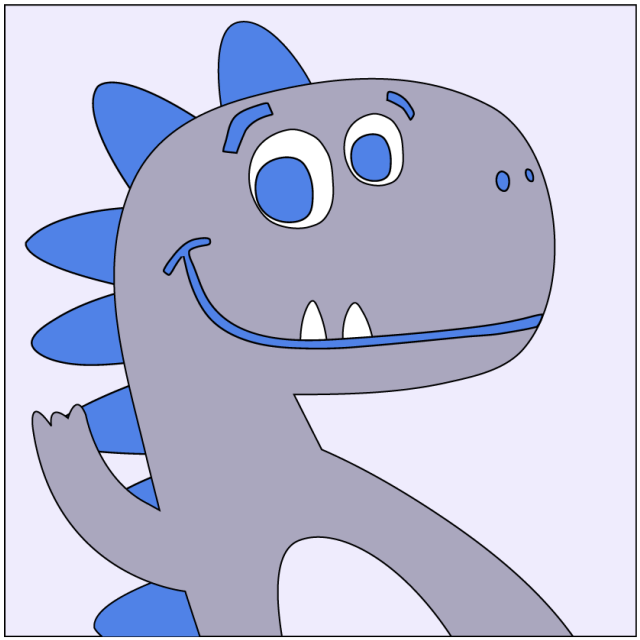
I suspect GPT-4's performance is influenced by data contamination, at least on Codeforces.

Of the easiest problems on Codeforces, it solved 10/10 pre-2021 problems and 0/10 recent problems.

Tweet übersetzen

g's Race	implementation, math		greedy, implementation
nd Chocolate	implementation, math	Cat?	implementation, strings
triangle!	brute force, geometry, math	Actions	data structures, greedy, implementation, math
	greedy, implementation, math	Interview Problem	brute force, implementation, strings
Numbers	brute force	wers	brute force, implementation, strings
ine Line	implementation	nd Suffix Array	strings
r or Stairs?	implementation	ther Promotion	greedy, math
Loves 3 I	math	Forces	greedy, sortings
s	implementation, math	d and Append	implementation, two pointers
	greedy, implementation, sortings	ng Directions	geometry, implementation

TIREx to the Rescue?



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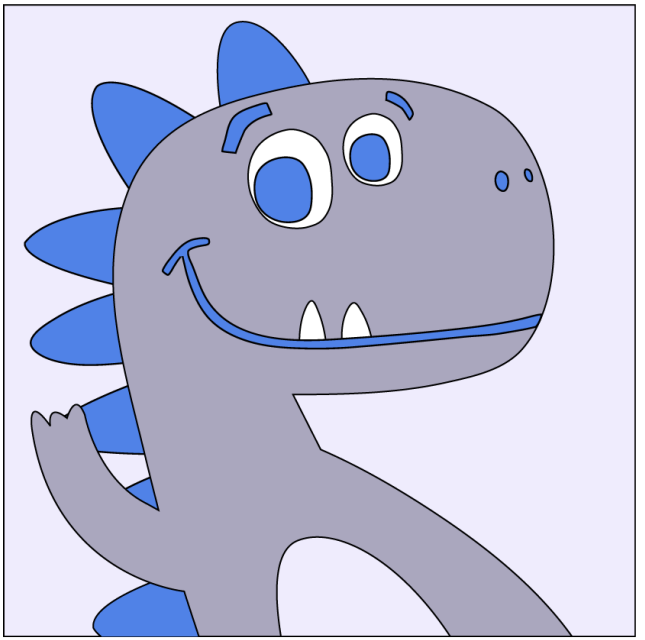


TIREx does “one thing”: Integrate Existing Tools

TIRA

- Reproducible shared tasks: Software submissions + blinded experiments

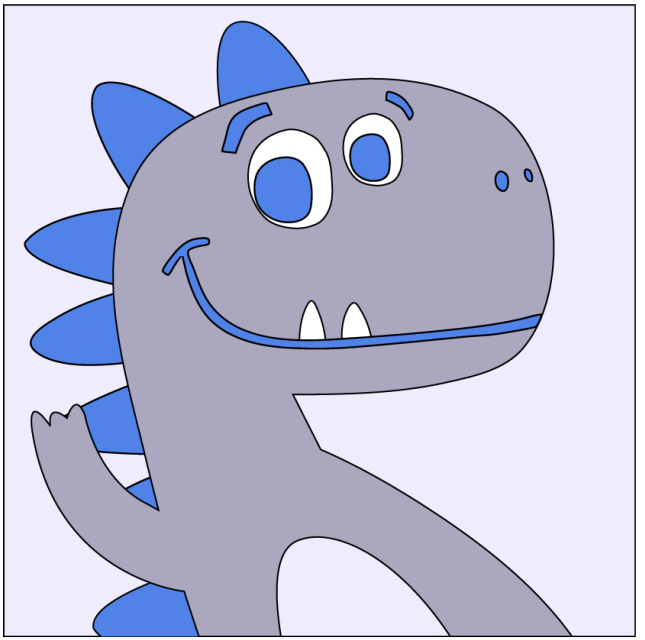
ir_datasets

- Unified + random data access: Documents + queries + rel. judgments

PyTerrier

- Declarative reproducibility pipelines

TIREx to the Rescue?



TIREx does “one thing”: Integrate Existing Tools

TIRA **Improves internal validity** **No Leakage for LLMs**

- Reproducible shared tasks: Software submissions + blinded experiments

ir_datasets **Improves external validity**

- Unified + random data access: Documents + queries + rel. judgments

PyTerrier

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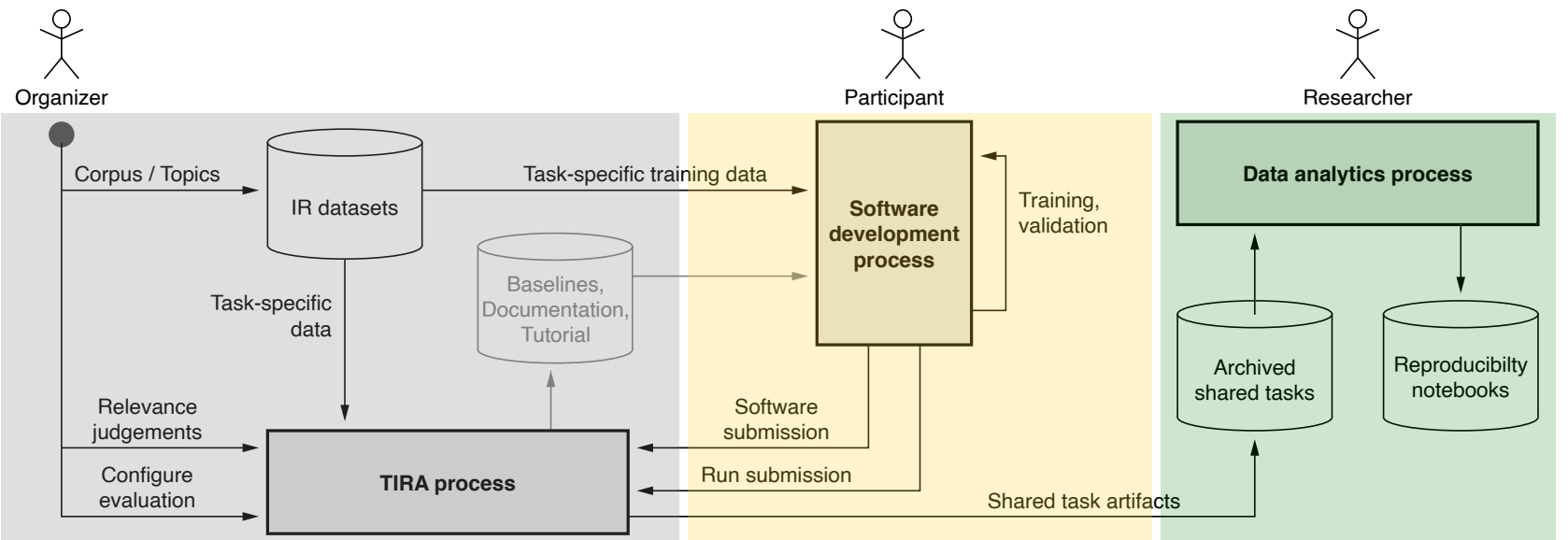
TIREx: Overview

- Organizer provides (private) Docker image with ir_datasets integration
- Participants provide Docker images with retrieval approaches

Covers a shared task end-to-end



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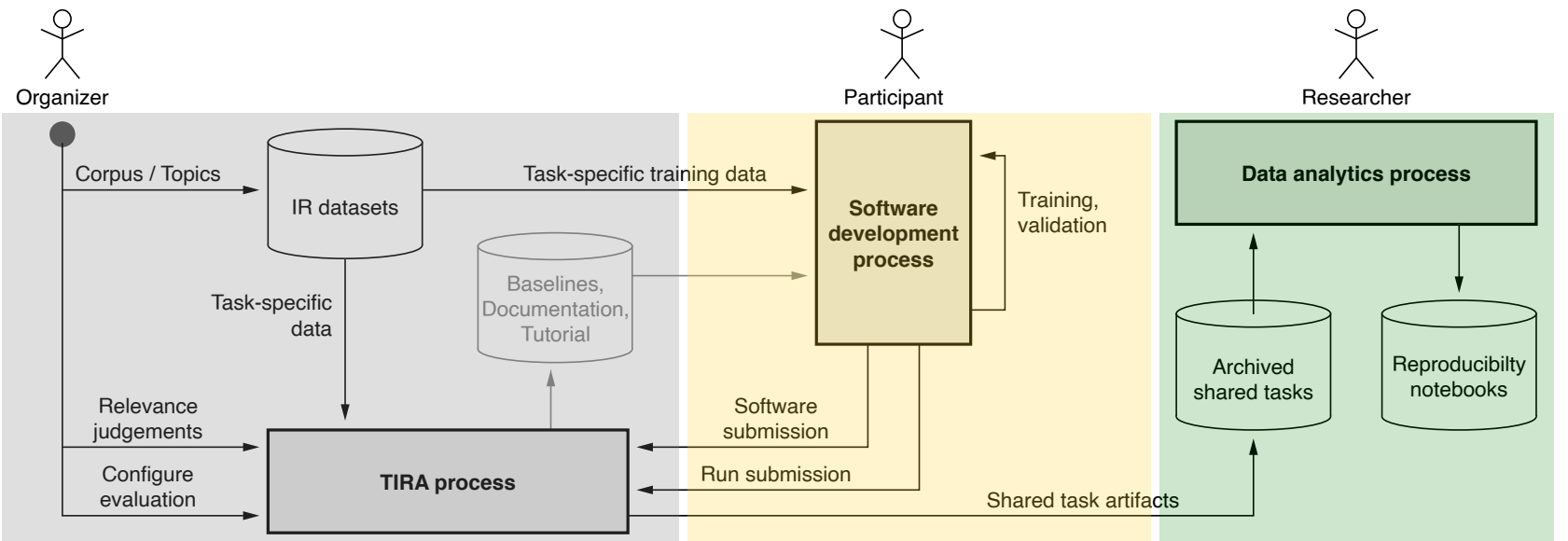

Advantages of software submissions via Docker:

- Executed in a sandbox → blinded experimentation
- Re-execution on same/similar data → improves reproducibility + replicability

TIREx: Feasibility Study

50 Transferrable Retrieval Models in TIRA

- Derived from tira-starters from 4 starters
- Retrieve against default text in ir_datasets
- Selecting suitable baseline → improves internal validity
- Diversification of pools for shared tasks with few participants

Framework	Type	Description	Systems
BEIR [78]	Bi-Encoder	Dense Retrieval	17
ChatNoir [7]	BM25F Retrieval	Elasticsearch Cluster	1
ColBERT@PT [55]	Late Interaction	Pyterrier Plugin	1
DuoT5@PT [71]	Cross-Encoder	Pairwise Transformer	3
PyGaggle [59]	Cross-Encoder	Pointwise Transformer	8
PyTerrier [64]	Lexical	Traditional Baselines	20
$\sum = 6 = 4$ frameworks + 2 forks			50

TIREx: Feasibility Study

32 Exchangeable Benchmarks in TIRA

- Models can be transferred to new corpora ⇒ improves external validity

Corpus			Included Benchmarks	
Name	Docs.	Size	Details	#
Args.me	0.4 m	8.3 GB	Touché 2020–2021 [9, 10]	2
Antique	0.4 m	90.0 MB	QA Benchmark [47]	1
ClueWeb09	1.0 b	4.0 TB	Web Tracks 2009–2012 [22–25]	4
ClueWeb12	731.7 m	4.5 TB	Web Tracks [29, 30], Touche [9, 10]	4
ClueWeb22B	200.0 m	6.8 TB	Touché 2023 [8] (ongoing)	1
CORD-19	0.2 m	7.1 GB	TREC-COVID [85, 90]	1
Cranfield	1,400	0.5 MB	Fully Judged Corpus [27, 28]	1
Disks4+5	0.5 m	602.5 GB	TREC-7/8 [87, 88], Robust04 [81, 82]	3
Gov	1.2 m	4.6 GB	Web Tracks 2002–2004 [32–34]	3
Gov2	25.2 m	87.1 GB	TREC TB 2004–2006 [18, 21, 26]	3
Medline	3.7 m	5.1 GB	Trec Genomics [48, 49], PM [73, 74]	4
MS MARCO	8.8 m	2.9 GB	Deep Learning 2019–2020 [35, 36]	2
NFCorpus	3,633	30.0 MB	Medical LTR Benchmark [12]	1
Vaswani	11,429	2.1 MB	Scientific Abstracts	1
WaPo	0.6 m	1.6 GB	Core 2018	1
$\sum$ = 15 corpora	1.9 b	15.3 TB		32

TIREx: Feasibility Study

Initial Leaderboards: 1600 runs

- Running all 50 models on all benchmarks took 1 Week
- See https://github.com/tira-io/ir-experiment-platform
- Additional use-cases: LTR, QPP, etc.

Teaser of results:

- Observe system preferences on TREC DL 2019
- Use repro_eval to measure the proportion of reproducible preferences [Breuer'20,Breuer'21]

Benchmark	Rank	Succ.
TREC DL 2020	1	85.2
Touché 20 (Task 2)	2	81.0
Touché 21 (Task 2)	3	72.6
Web Track 2004	4	72.1
CORD-19	5	70.0
Terabyte 2006	10	62.1
TREC PM 2017	15	53.4
Terabyte 2005	20	42.2
TREC PM 2018	25	33.2
Cranfield	30	28.8

TIREx: Conclusion

Integration of existing tools

- TIRA, ir_datasets, PyTerrier

Better benefit/effort ratio then previous approaches for shared tasks?

- One software submission, evaluation on many datasets
- Evaluate on datasets to which you dont have access

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Future Work

- Move to generative IR (integration of Alpaca)
- Integration of cloud infrastructure of the Open Search Foundation
- Render SERPs with DiffIR
- We would be happy to help you with your shared task!

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github.com/tira-io/tira

Thank You!

Backup: SemEval’23 ValueEval Demo (1)

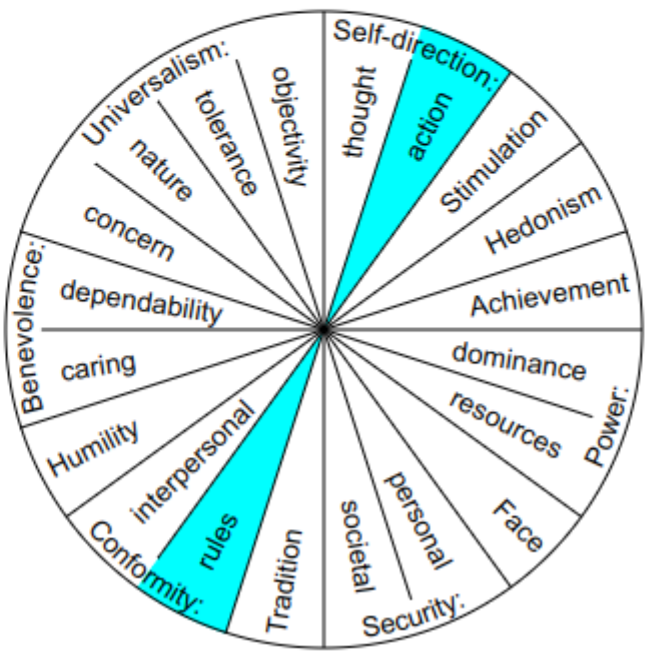
Human Value Detection Demo

Demo for the Adam Smith human value detector by Schroter et al. (2023) [paper under review], which performed best in the ValueEval'23 c
ensemble of three models that performed best in the ablation tests. [code: original, docker image, server docker image]

Enter an argument in the text area and click on submit. After a few seconds, the detected value categories will be highlighted in the value ta

Speed limits should be abonded.

Submit



Backup: SemEval’23 ValueEval Demo (2)

We should allow gay marriage

Submit

Backup: Limitations

- Computational resources.
  Potential Solution:
  - Hybrid submissions: Run upload, Software submission only for plausibility checks
  -
  - OSF infrastructure
- How to avoid big ensembles?
- Evaluation measures required that combine efficiency with effectiveness?
- New iteration of the IRF?

Backup: Use in Teaching

- Cover the “full cycle” with students in IR exercises?
  - We do this next term

Backup: Definition of Multi-Stage Software

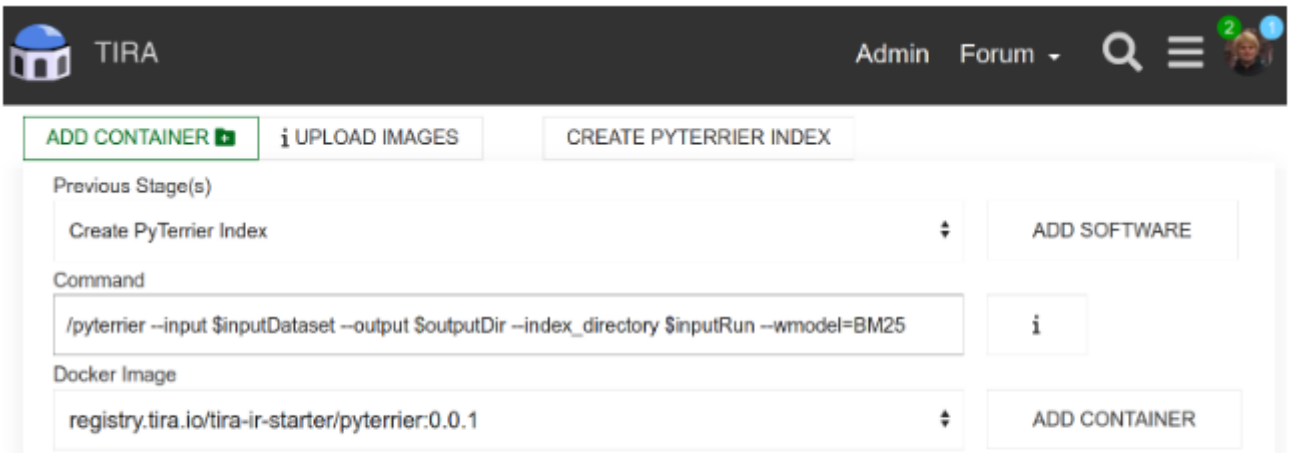


Figure 3: The definition of a full-rank retrieval software in TIRA that consists of two modularized components.

Backup: Full-Rank

```
pipeline = tira.pt.retriever(
    '<task-name>/<user-name>/software',
    dataset
)
advanced_pipeline = pipeline >> advanced_reranker
```

Listing 1: Full-Rank Retrieval from a complete corpus.

Backup: Load Submissions

```
first_stage = tira.pt.from_submission(
    '<task-name>/<user-name>/<software>',
    dataset='<dataset>'
)
advanced_pipeline = first_stage >> advanced_reranker
```

Listing 3: Re-Rank a run created by a software submission.