Benchmarking for the real world: Diversity in optimisation problems

but first one slide about:

A short overview and common pitfalls of benchmarking evolutionary algorithms

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Vanessa Volz, Dani Irawan,
Koen van der Blom & **Boris Naujoks**

A short overview and common pitfalls of benchmarking evolutionary algorithms

Focus on multi-/many-objective optimisation

Overview of existing benchmarks

- Artificial
- Includes, e.g., BBOB which has both single- and multi-objective
- Real-world
- Not exhaustive, but a start

Benchmarking pitfalls

- Grouped by: Problem choice, analysis and evaluation, benchmark usage
- Checklist to avoid pitfalls

`http://www.gm.fh-koeln.de/~naujoks/Pub.d/VIBN22.pdf`

Benchmarking for the real world: Diversity in optimisation problems

Koen van der Blom, Timo Deist, Mariapia Marchi, **Boris Naujoks**,
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Real-world problems, easy or hard?

Literature / talks

- *“real-world problems are complex and hard to optimise”*
- *“real-world problems are easier than expected”*

What is the truth?

Real-world problems in benchmarks

Artificial benchmarks

- Entirely artificial problems
- Include problems inspired by known real-world problems

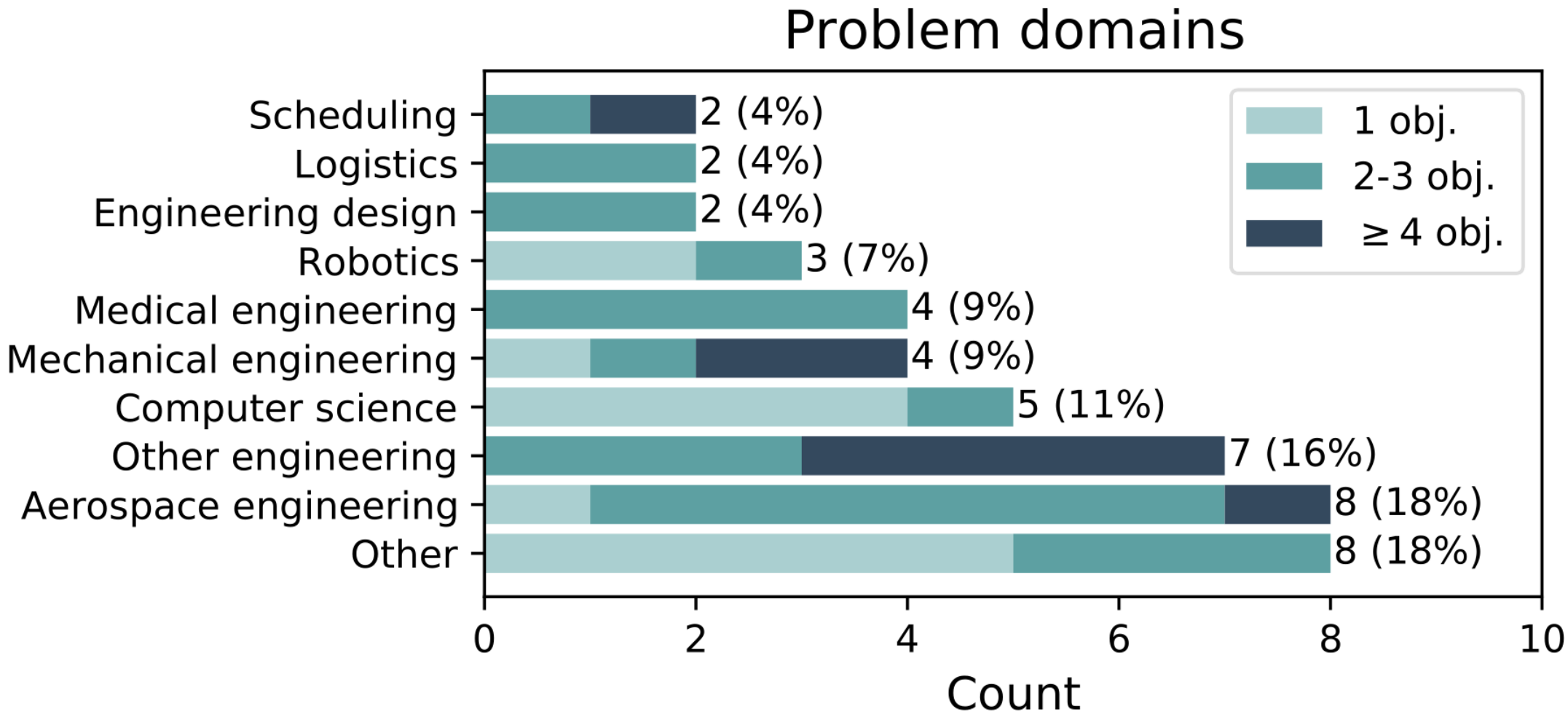
Real-world benchmarks

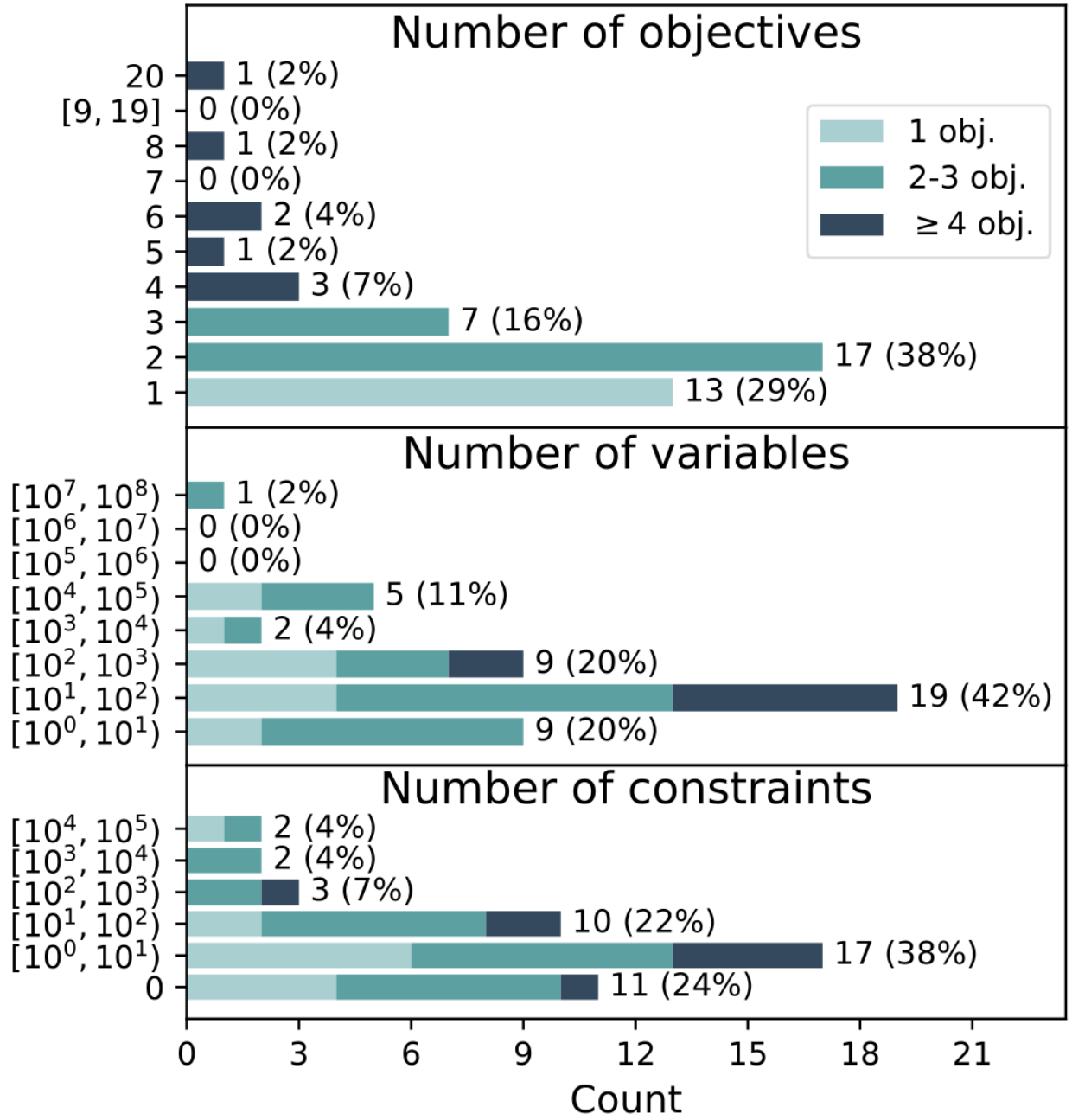
- Some exist

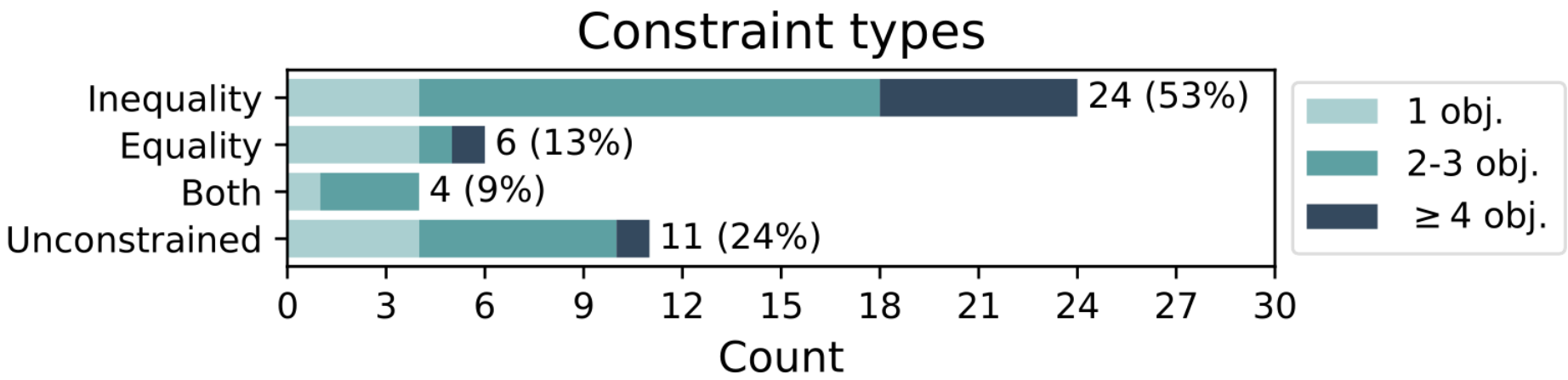
How well do artificial and real-world benchmarks connect to ‘general’ real-world problems?

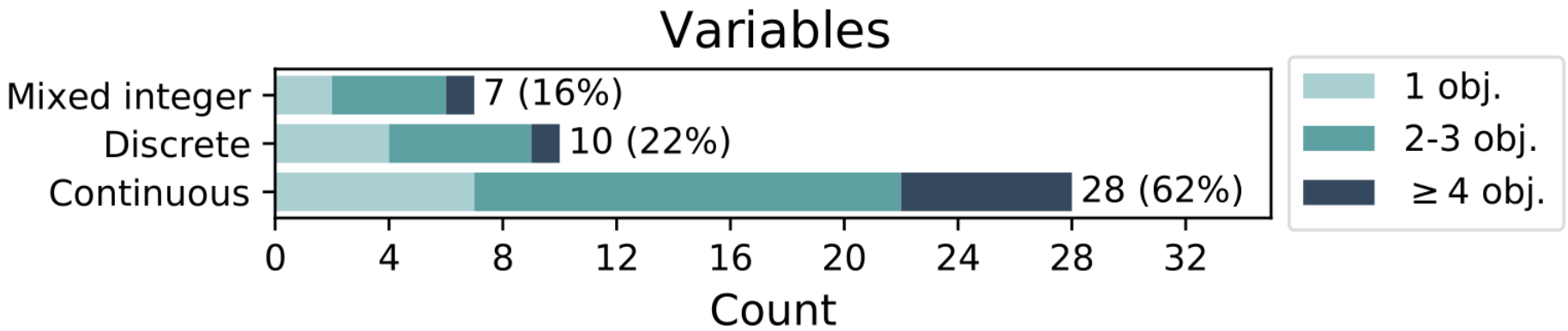
Questionnaire

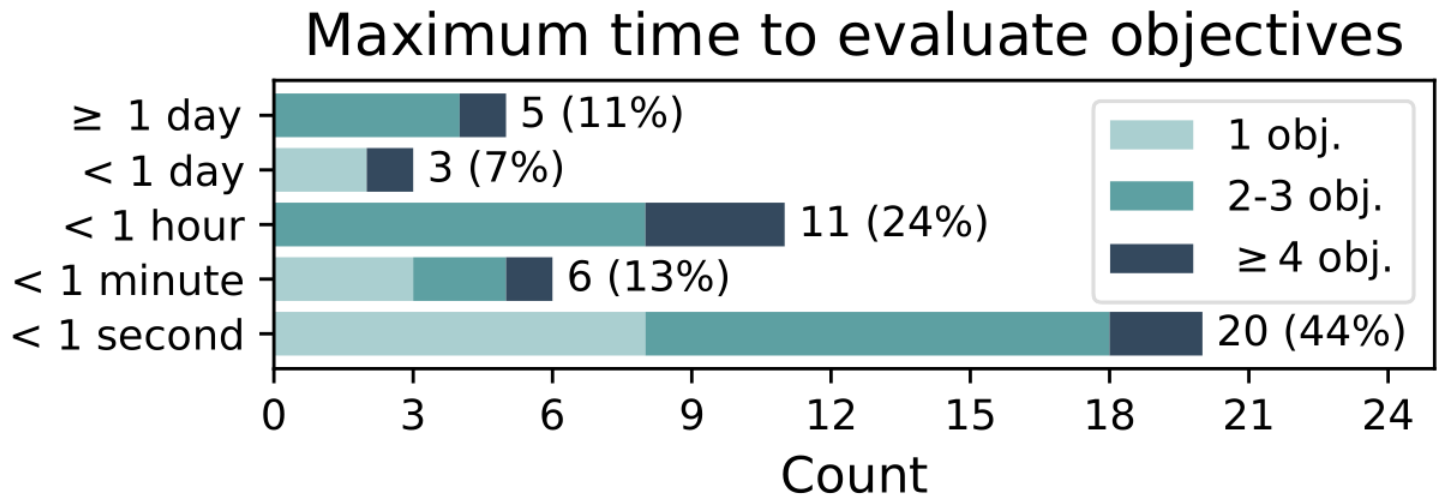
- What is the reality?
- 45 responses with real-world problems
- A basis for discussion, as opposed to our individual experiences
- Possibly starting point for other question:
  - What is and is not covered by existing benchmarks?

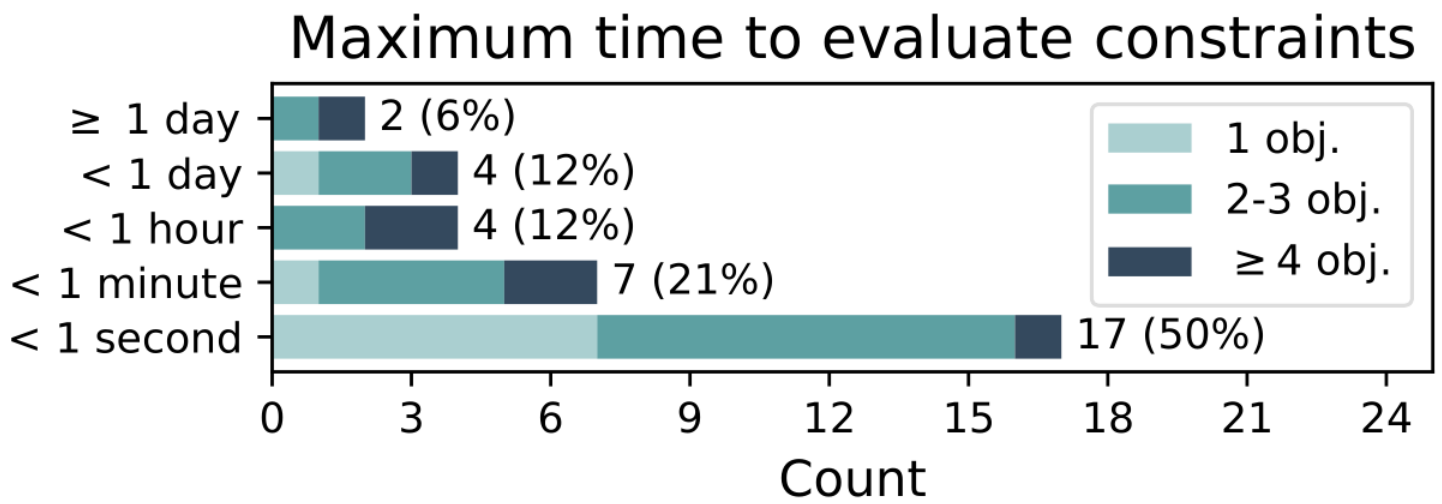

Problem domains
Scheduling
Logistics
Engineering design
Robotics
Medical engineering
Mechanical engineering
Computer science
Other engineering
Aerospace engineering
Other
2 (4%)
2 (4%)
2 (4%)
3 (7%)
4 (9%)
4 (9%)
5 (11%)
7 (16%)
8 (18%)
8 (18%)
1 obj.
2-3 obj.
≥ 4 obj.
0
2
4
6
8
10
Count

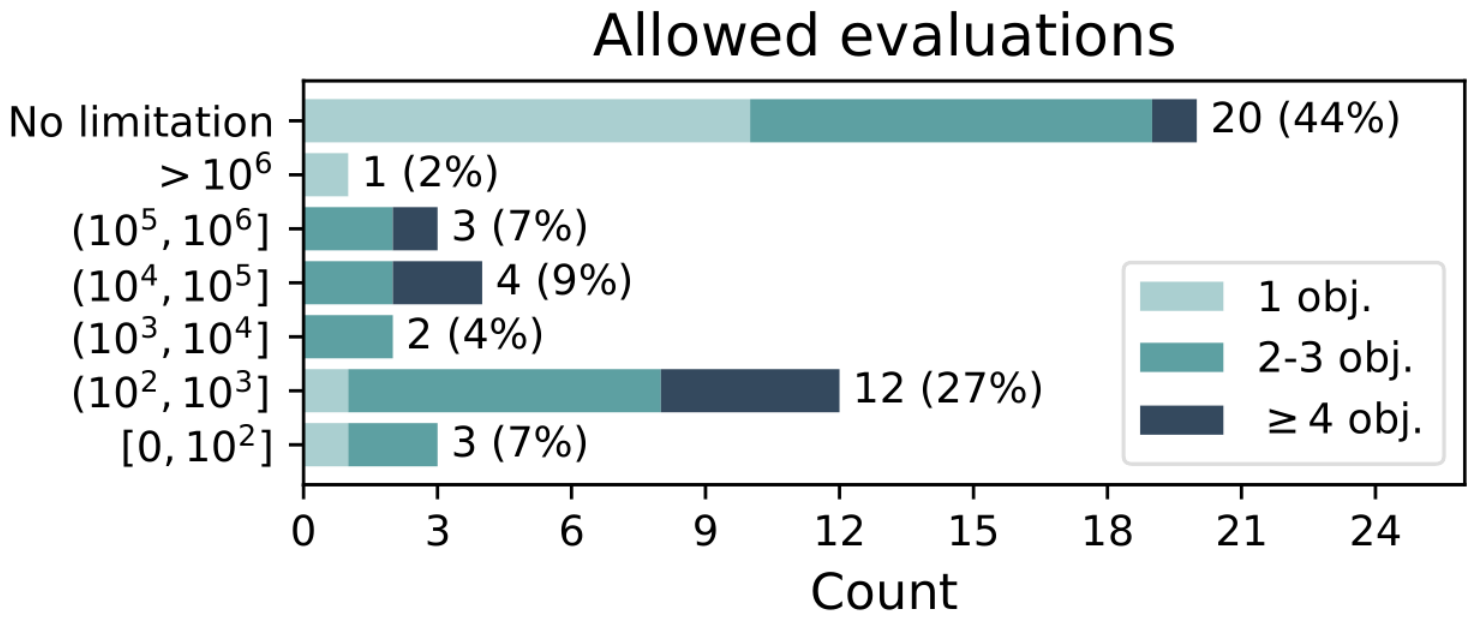

Number of objectives
20
[9, 19]
8
7
6
5
4
3
2
1
1 (2%)
0 (0%)
1 (2%)
0 (0%)
2 (4%)
1 (2%)
3 (7%)
7 (16%)
17 (38%)
13 (29%)
1 obj.
2-3 obj.
≥ 4 obj.
Number of variables
[10^7, 10^8)
[10^6, 10^7)
[10^5, 10^6)
[10^4, 10^5)
[10^3, 10^4)
[10^2, 10^3)
[10^1, 10^2)
[10^0, 10^1)
1 (2%)
0 (0%)
0 (0%)
5 (11%)
2 (4%)
9 (20%)
19 (42%)
9 (20%)
Number of constraints
[10^4, 10^5)
[10^3, 10^4)
[10^2, 10^3)
[10^1, 10^2)
[10^0, 10^1)
0
2 (4%)
2 (4%)
3 (7%)
10 (22%)
17 (38%)
11 (24%)
0
3
6
9
12
15
18
21
Count

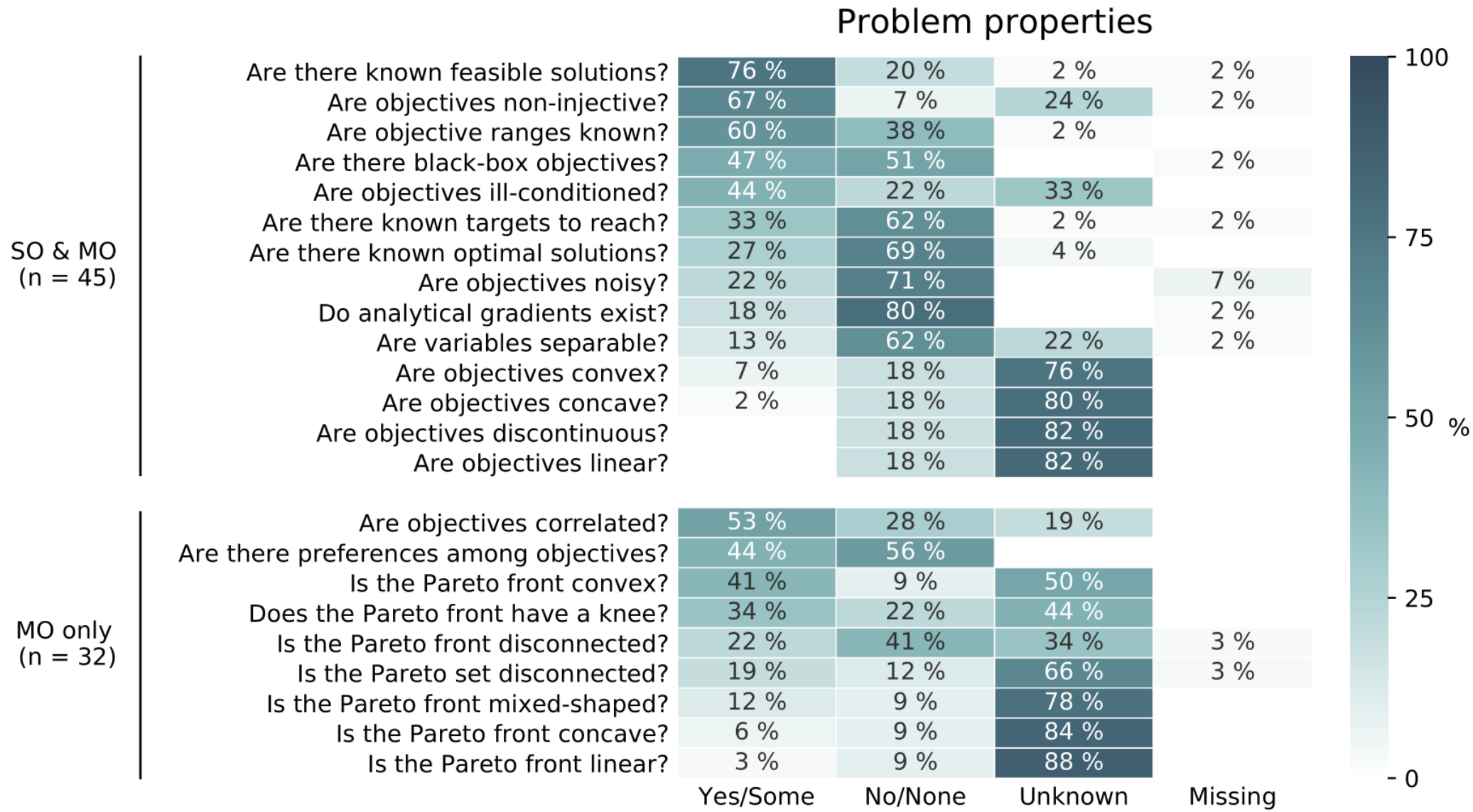

Constraint types
Inequality
Equality
Both
Unconstrained
24 (53%)
6 (13%)
4 (9%)
11 (24%)
0
3
6
9
12
15
18
21
24
27
30
Count
1 obj.
2-3 obj.
≥ 4 obj.

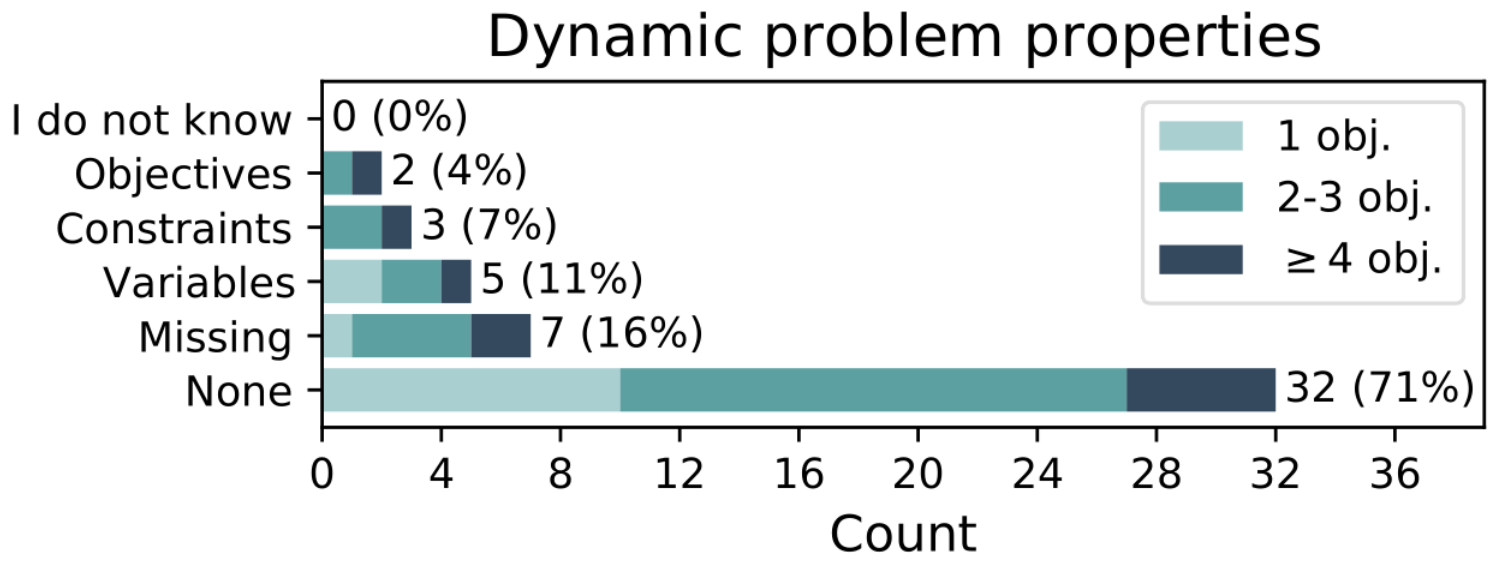

Variables
Mixed integer
Discrete
Continuous
7 (16%)
10 (22%)
28 (62%)
0
4
8
12
16
20
24
28
32
Count
1 obj.
2-3 obj.
≥ 4 obj.

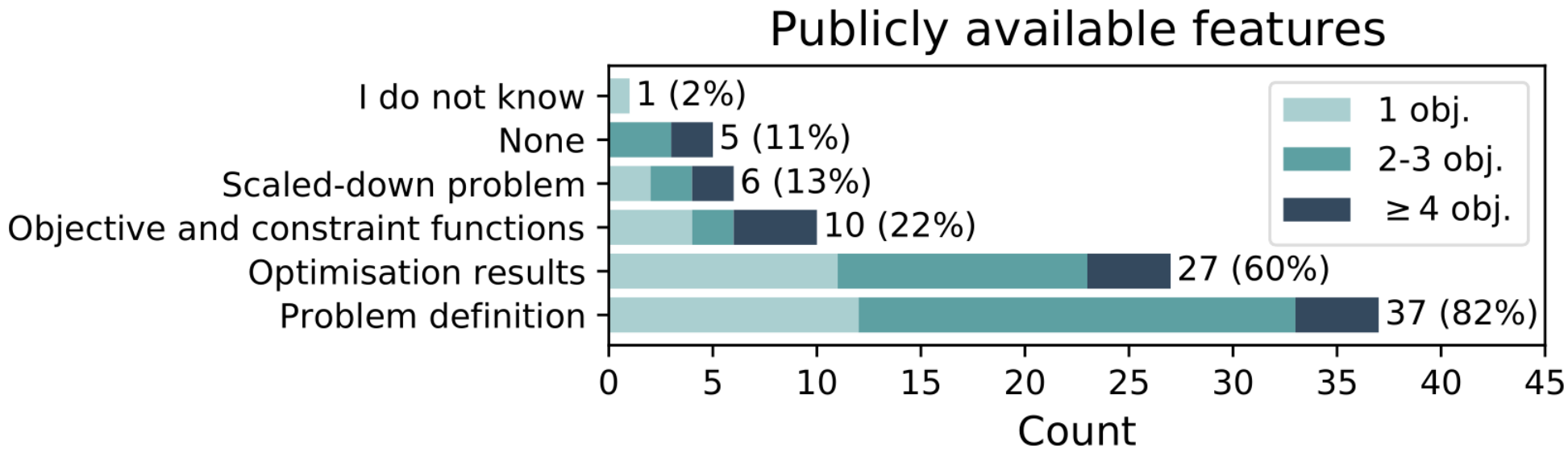

Maximum time to evaluate objectives
≥ 1 day
< 1 day
< 1 hour
< 1 minute
< 1 second
5 (11%)
3 (7%)
11 (24%)
6 (13%)
20 (44%)
1 obj.
2-3 obj.
≥ 4 obj.
0
3
6
9
12
15
18
21
24
Count


Maximum time to evaluate constraints
≥ 1 day
< 1 day
< 1 hour
< 1 minute
< 1 second
2 (6%)
4 (12%)
4 (12%)
7 (21%)
17 (50%)
1 obj.
2-3 obj.
≥ 4 obj.
0
3
6
9
12
15
18
21
24
Count


Allowed evaluations
No limitation
$> 10^6$
$(10^5, 10^6]$
$(10^4, 10^5]$
$(10^3, 10^4]$
$(10^2, 10^3]$
$[0, 10^2]$
20 (44%)
1 (2%)
3 (7%)
4 (9%)
2 (4%)
12 (27%)
3 (7%)
1 obj.
2-3 obj.
≥ 4 obj.
0
3
6
9
12
15
18
21
24
Count


Problem properties
SO & MO (n = 45)
MO only (n = 32)
Are there known feasible solutions? 76 % 20 % 2 % 2 %
Are objectives non-injective? 67 % 7 % 24 % 2 %
Are objective ranges known? 60 % 38 % 2 %
Are there black-box objectives? 47 % 51 % 2 %
Are objectives ill-conditioned? 44 % 22 % 33 %
Are there known targets to reach? 33 % 62 % 2 % 2 %
Are there known optimal solutions? 27 % 69 % 4 %
Are objectives noisy? 22 % 71 % 7 %
Do analytical gradients exist? 18 % 80 % 2 %
Are variables separable? 13 % 62 % 22 % 2 %
Are objectives convex? 7 % 18 % 76 %
Are objectives concave? 2 % 18 % 80 %
Are objectives discontinuous? 18 % 82 %
Are objectives linear? 18 % 82 %
Are objectives correlated? 53 % 28 % 19 %
Are there preferences among objectives? 44 % 56 %
Is the Pareto front convex? 41 % 9 % 50 %
Does the Pareto front have a knee? 34 % 22 % 44 %
Is the Pareto front disconnected? 22 % 41 % 34 % 3 %
Is the Pareto set disconnected? 19 % 12 % 66 % 3 %
Is the Pareto front mixed-shaped? 12 % 9 % 78 %
Is the Pareto front concave? 6 % 9 % 84 %
Is the Pareto front linear? 3 % 9 % 88 %
Yes/Some
No/None
Unknown
Missing
100
75
50
25
0
%


Dynamic problem properties
I do not know
Objectives
Constraints
Variables
Missing
None
0 (0%)
2 (4%)
3 (7%)
5 (11%)
7 (16%)
32 (71%)
1 obj.
2-3 obj.
≥ 4 obj.
0
4
8
12
16
20
24
28
32
36
Count


Publicly available features
I do not know
None
Scaled-down problem
Objective and constraint functions
Optimisation results
Problem definition
1 (2%)
5 (11%)
6 (13%)
10 (22%)
27 (60%)
37 (82%)
1 obj.
2-3 obj.
≥ 4 obj.
0
5
10
15
20
25
30
35
40
45
Count

Real-world optimisation problems are diverse (in many aspects)

New benchmarks

- Fill gaps
- Can take into account connection to real-world

Future

- Currently no concrete plan for next steps
- Questionnaire still open
- Happy to share data!
  - Current data on the website
  - If new data, happy to make it available

Book chapter + more info on the website: `https://sites.google.com/view/macoda-rwp/`