Data Enrichment in Fine-Grained Classification of Aquatic Macroinvertebrates

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What is the need for “bug” identification?

- Used as indicators in mandatory aquatic biomonitoring (e.g. EU-WFD / MSD)
- High number of taxa to be identified (classes)
- Lot of human expert cost/time needed to classify
- Less human experts available
- Biomonitoring currently suffers from budget cuts

Image Classification

- The standard image classification pipeline is based on engineered features, e.g. SIFT, HOG, etc.
- Baseline image classification for the approach using engineered features:
  - Image description
  - Image representation
  - Image classification

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Image Classification using Deep Nets

- Combined model for:
  - Image description
  - Image representation
  - Image classification
- The parameters of all processing steps are optimized for the specific task at hand

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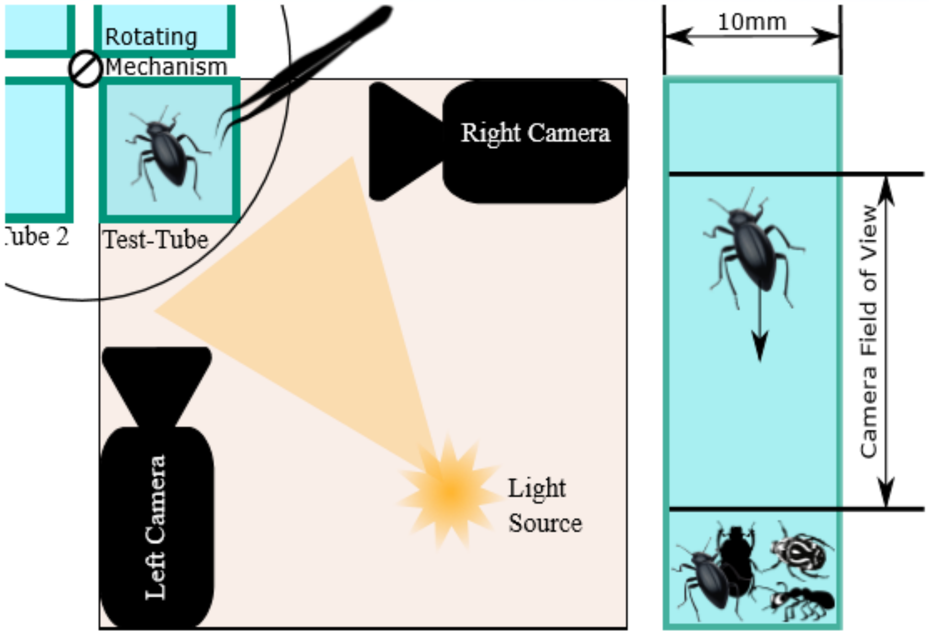
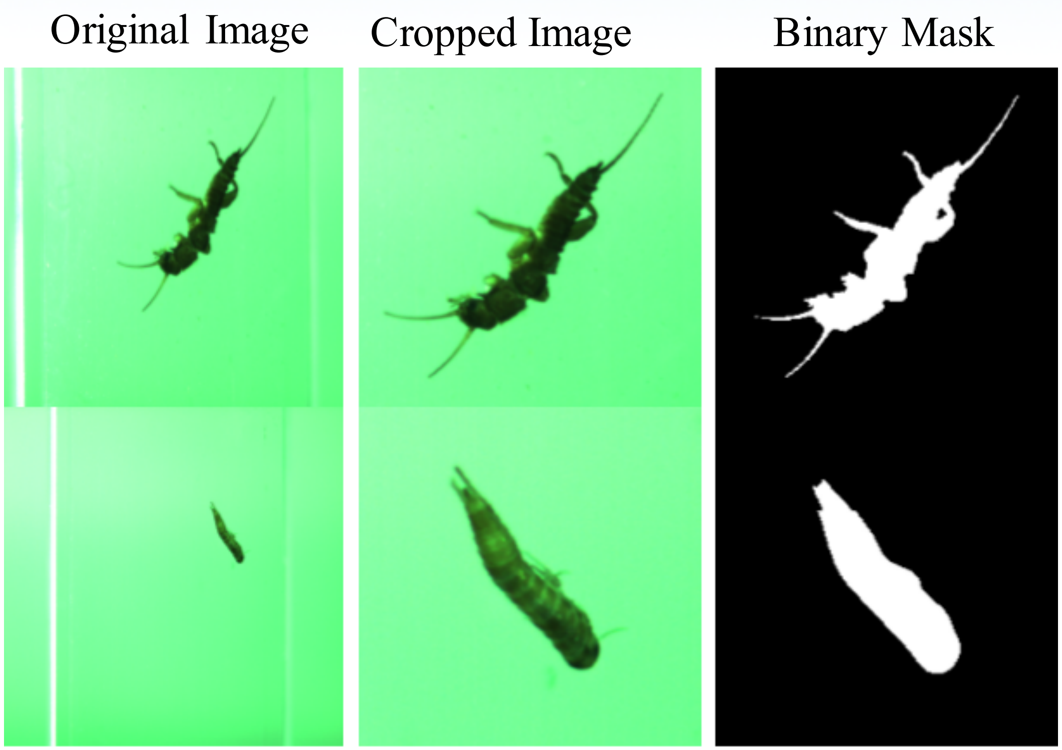
Experimental Setup

➢ Data collection



Experimental Setup

- Pre-processing

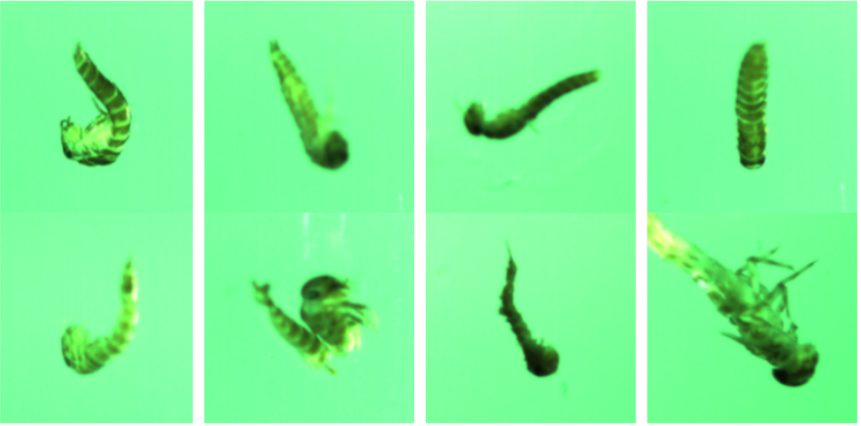


Experimental Setup

- Multi-class classification:
  - 29 classes
- Challenges:
  - High intra-class variations
  - Low inter-class variations

Class 5

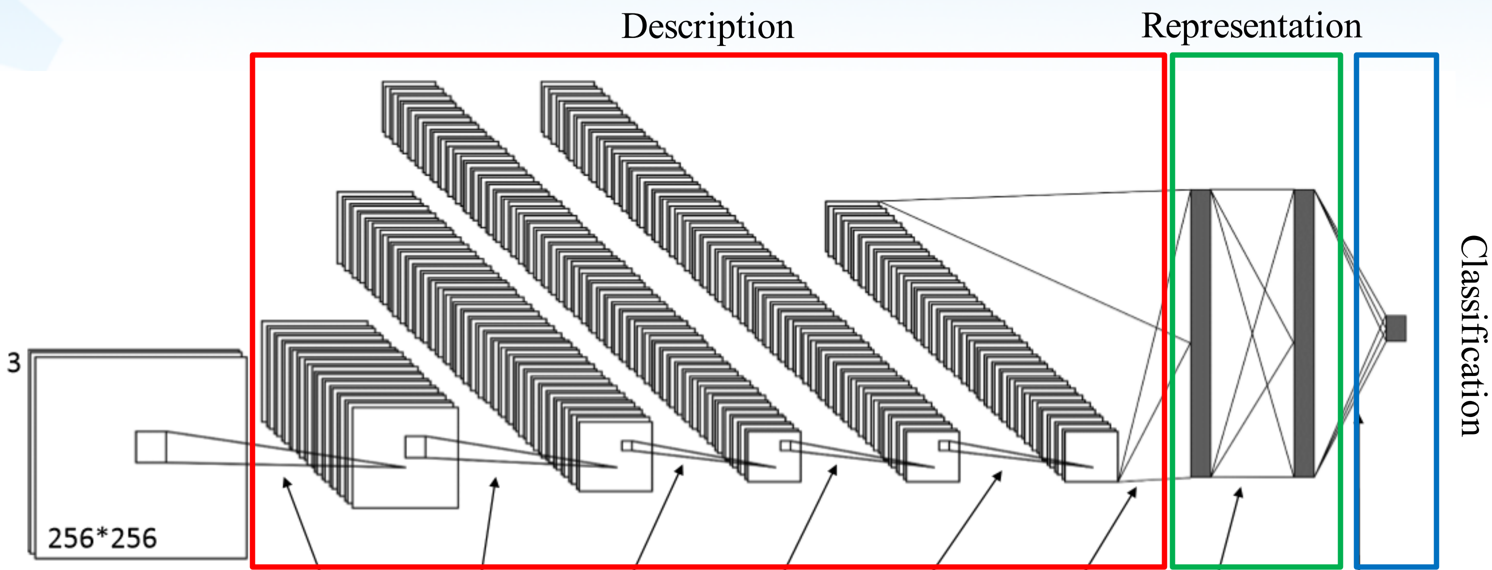
Class 1



#	Macroinvertebrate taxon	Orig. no. of images
1	*Ameletus inopinatus*	343
2	*Asellus aquaticus*	447
3	*Atherix ibis*	230
5	*Baetis niger*	455
4	*Baetis rhodani*	468
6	Ceratopogonidae	322
7	*Dicranota* sp.	367
8	*Elmis aenea*	468
9	*Elmis aenea* adult	378
10	*Ephemerella aroni (aurivillii)*	577
11	*Habrophlebia* sp.	458
12	*Hemerodromia* sp.	280
13	*Heptagenia dalecarlica*	409
14	*Hydraena* adult	436
15	*Isoperla* sp.	460
16	*Itytrichia lamellaris*	428
17	*Leptophlebia* sp.	480
18	*Leuctra* sp.	378
19	*Limnius volckmari* adult	395
20	*Micrasema gelidum*	417
21	*Micrasema setiferum*	372
22	*Nemoura* sp.	414
23	*Oulimnius tuberculatus*	465
24	*Oxyethira* sp.	438
25	*Philopotamus montanus*	330
26	Psychodiidae	408
27	*Protonemura* sp.	387
28	Simuliidae	418
29	*Taeniopteryx nebulosa*	404

Image Classification using Deep Nets

- AlexNet model



	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8
Type	conv+max +norm	conv+max +norm	conv	conv	conv+max	fully connected	fully connected	fully connected
Channels	96	256	384	384	256	4096	4096	29
Filter size	11x11	5x5	3x3	3x3	3x3			
Input size	227*227	55*55	27*27	13*13	13*13			

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Data enrichment

- Data enrichment approaches have been shown to enhance the performance of classification schemes due to:
    - They provide examples that might appear in the evaluation phase
    - They provide a larger dataset that can be used in order to better estimate the parameters of the classification model (especially in neural networks having an enormous number of parameters)

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Data enrichment

- We have used two types of enrichment:
  - Horizontal and vertical flipping
  - Rotation with random angles

#	Macroinvertebrate taxon	Orig. no. of images	Expansion factor
1	*Ameletus inopinatus*	343	5
2	*Asellus aquaticus*	447	4
3	*Atherix ibis*	230	8
5	*Baetis niger*	455	4
4	*Baetis rhodani*	468	4
6	Ceratopogonidae	322	5
7	*Dicranota* sp.	367	5
8	*Elmis aenea*	468	4
9	*Elmis aenea* adult	378	4
10	*Ephemerella aroni (aurivillii)*	577	3
11	*Habrophlebia* sp.	458	4
12	*Hemerodromia* sp.	280	7
13	*Heptagenia dalecarlica*	409	4
14	*Hydraena* adult	436	4
15	*Isoperla* sp.	460	4
16	*Itytrichia lamellaris*	428	4
17	*Leptophlebia* sp.	480	4
18	*Leuctra* sp.	378	5
19	*Limnius volckmari* adult	395	4
20	*Micrasema gelidum*	417	4
21	*Micrasema setiferum*	372	5
22	*Nemoura* sp.	414	4
23	*Oulimnius tuberculatus*	465	4
24	*Oxyethira* sp.	438	4
25	*Philopotamus montanus*	330	5
26	Psychodiidae	408	4
27	*Protonemura* sp.	387	5
28	Simuliidae	418	4
29	*Taeniopteryx nebulosa*	404	4

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Experiments

- We applied ten experiments:
  - On each experiment we split each class in 50% training, 20% validation and 30% test samples
  - We measure the performance of each method using classification rate metric
  - We report the mean classification rate and the corresponding standard deviation over all ten experiments

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Experiments

- Results:

#	MatConvNet orig.	MatConvNet enriched	Caffe orig.*	Caffe enriched	Caffe pretrained orig.*	Caffe pretrained enriched
1	81.28	84.27	77.41	79.44	85.36	88.27
2	77.58	86.95	77.47	80.98	86.35	89.04
3	80.15	86.07	75.93	80.87	86.13	87.83
4	77.19	85.53	74.56	80.43	84.76	88.65
5	81.20	85.47	79.06	82.02	86.13	88.65
6	78.56	85.53	77.69	80.48	85.42	88.27
7	79.22	85.53	76.97	78.84	86.02	88.32
8	80.92	84.81	76.70	79.99	85.47	89.09
9	76.48	84.76	76.26	80.26	84.38	87.99
10	78.84	85.31	77.69	81.47	86.40	89.31
avg	79.14	85.42	76.97	80.48	85.64	88.54
std	1.72	0.74	1.22	0.93	0.69	0.49

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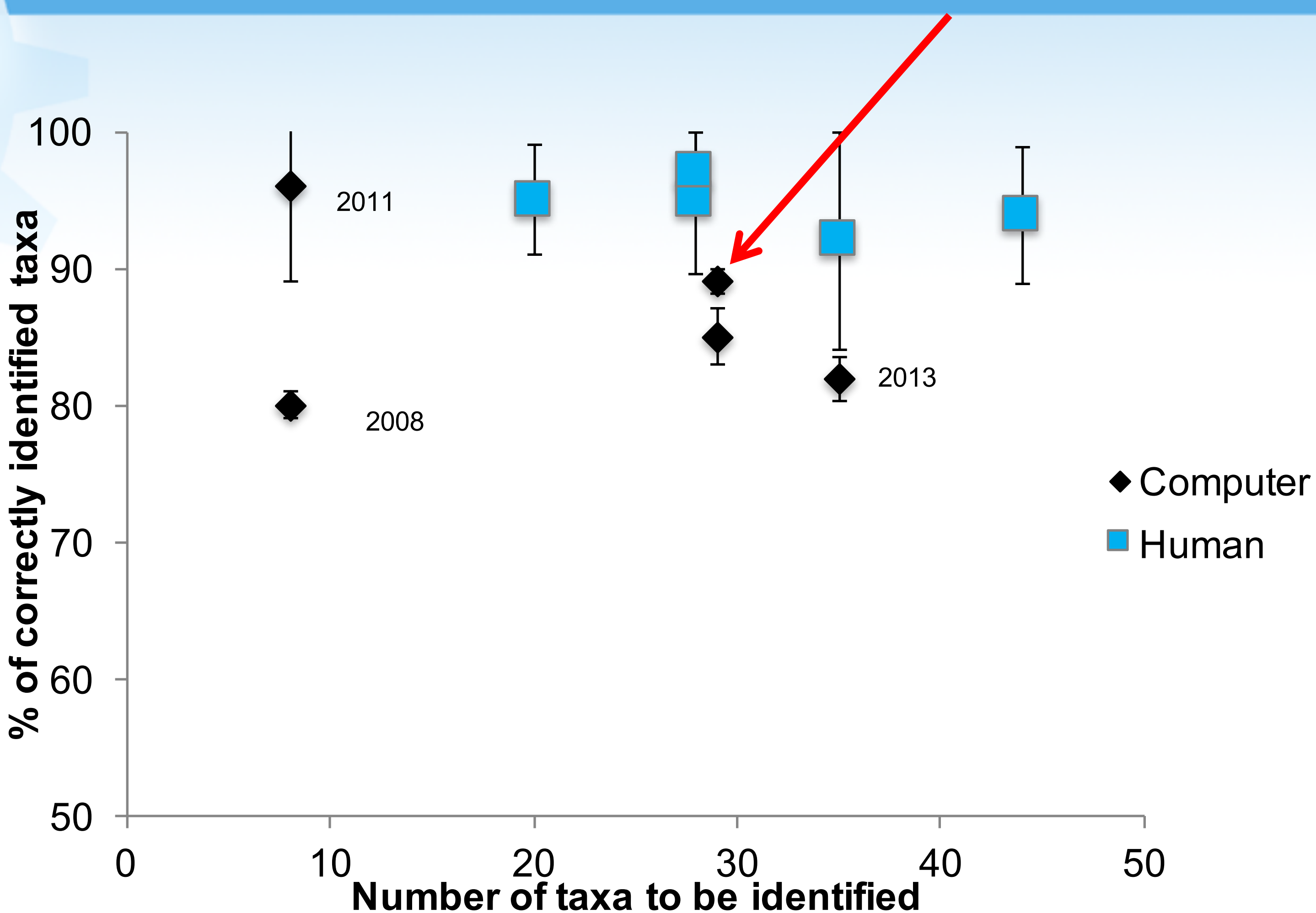
How do those results compare to professionals?



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Summary

- Achieved error rates are acceptable and within the range of those for human experts in proficiency tests

- Data enrichment enhances performance
- Pretrained networks work better

Next step:

- 126 class data set

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Thank you!

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