

# Inductive Programming

## Lecture 7

### Data Wrangling

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## Papers for this lecture

**Paper7.1** L. Contreras-Ochando, C. Ferri, J. Hernández-Orallo, F. Martinez-Plumed, M.J. Ramirez-Quintana General-purpose Declarative Inductive Programming with Domain-Specific Background Knowledge for Data Wrangling Automation, 2018

**Paper7.2:** A. Cropper, A. Tamaddoni-Nezhad and S.H. Muggleton. Meta-interpretive learning of data transformation programs. In Proceedings of the 25th International Conference on Inductive Logic Programming, pages 46-59. Springer-Verlag, 2016.

**Paper7.3:** A. Tamaddoni-Nezhad and g. Milani and A. Raybould and S.H. Muggleton and D.A. Bohan. Construction and Validation of Food Webs Using Logic-Based Machine Learning and Text Mining. In Advances in Ecological Research, Vol 49, pp 225-289. Elsevier, 2013.

## Motivation

- Inductive Programming
- Data Wrangling - transform raw data for analysis
- Large amount of effort writing small, error-prone programs
- Applications in Business, Science, Medicine
- Microsoft Research Redmond - Inductive Programming
- Academic Research

## Commercial Data Wrangling Video

- Microsoft Inductive Programming products - Sumit Gulwani
- YouTube - Data Wrangling using Programming by Examples
- <https://www.youtube.com/watch?v=XWRsxy8SbzY>

# Inductive Functional Programming Data Wrangling

## [Paper7.1]

Id	Input	Outputs
1	25-03-74	25/03/74
2	29-03-86	29/03/86
3	11-02-96	11/02/96
4	11-17-98	17/11/98
5	17-05-17	17/05/17
6	25-08-05	25/08/05
7	30-06-75	30/06/75
8	...	...

Dates with desired output format

## Materials and Method [Paper7.1]

id	Domain	#Ex.	Description
1	Freetext	12	Complete brackets (From [29])
2	...	...	...
6	Dates	26	Change the punctuation of a date (From [30])
7	...	...	...
14	Emails	24	Extract words after '@' (From [33] )
15	...	...	...
30	Units	12	Extract the units of a value (From [32])
31	...	...	...

**Table 6:** Data wrangling repository.  
<http://dmip.webs.upv.es/datawrangling/>

**Method:** MagicHaskeller

## Results [Paper7.1]

id	Domain	default	freetext	dates	...	all
1	freetext	0.00	<b>1.00</b>	0.00	...	0.00
...	...	...	...	...	...	...
6	dates	0.00	<b>1.00</b>	<b>1.00</b>	...	0.00
...	...	...	...	...	...	...
14	emails	0.00	0.04	0.04	...	0.00
...	...	...	...	...	...	...
30	units	0.64	0.18	0.18	...	0.00
...	...	...	...	...	...	...

**Table 7:** Accuracy depending on set of primitives (DSBK).  
Demonstrates Background **Relevance** problem.

## **Syngenta FoodWeb Project [Paper7.3]**

Machine Learned Food Web Paper7.3 Page 256



# Inductive Logic Programming Data Wrangling

## Extracting predation facts from Ecological papers.

[Paper7.2]

Input

Harpalus rufipes	eats	large prey such as	Lepidoptera	.
Bembidion lampros	:	In cereals the main	food	was Collembola .

## Ecological data output [Paper7.2]

Output

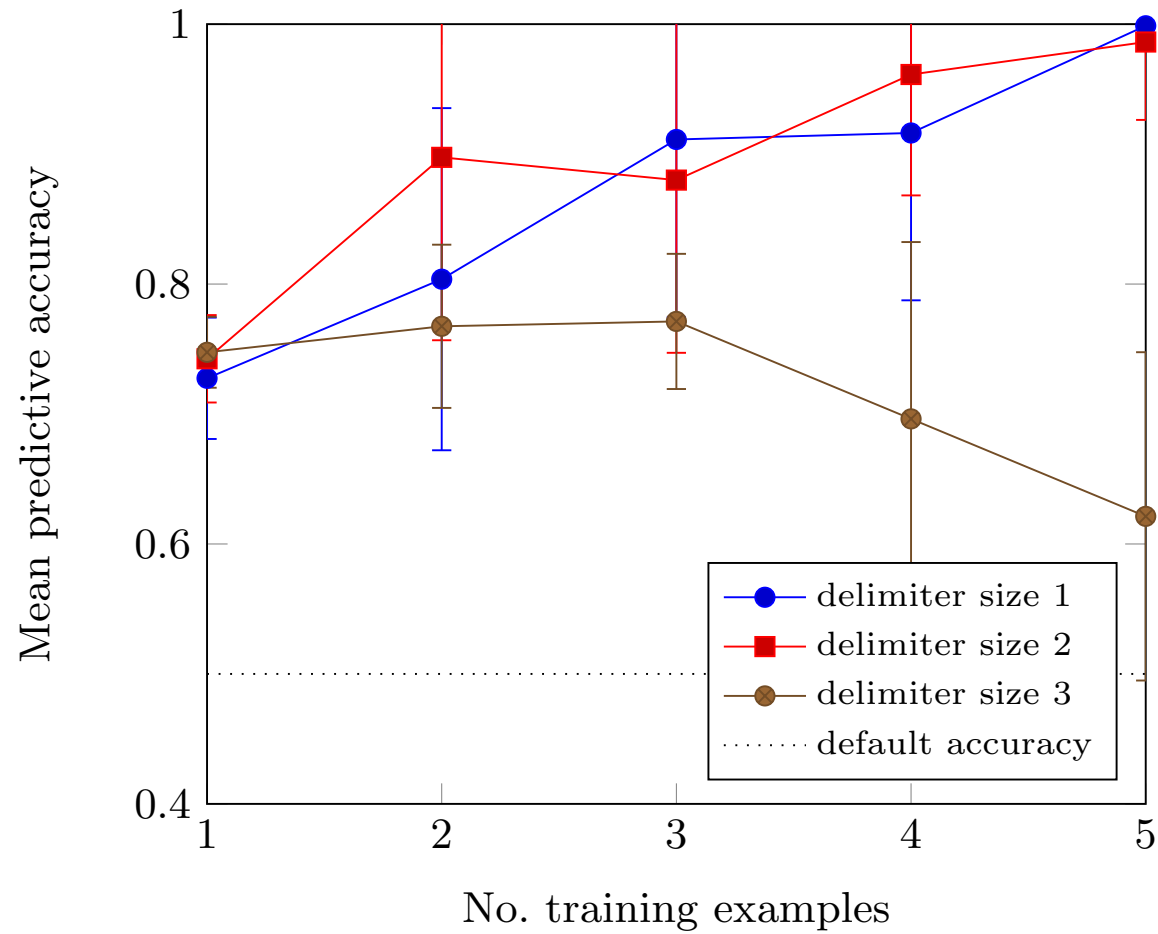
Harpalus rufipes		eats	Lepidoptera	
Bembidion lampros		food	Collembola	

## Ecological data Background Knowledge (BK) [Paper7.2]

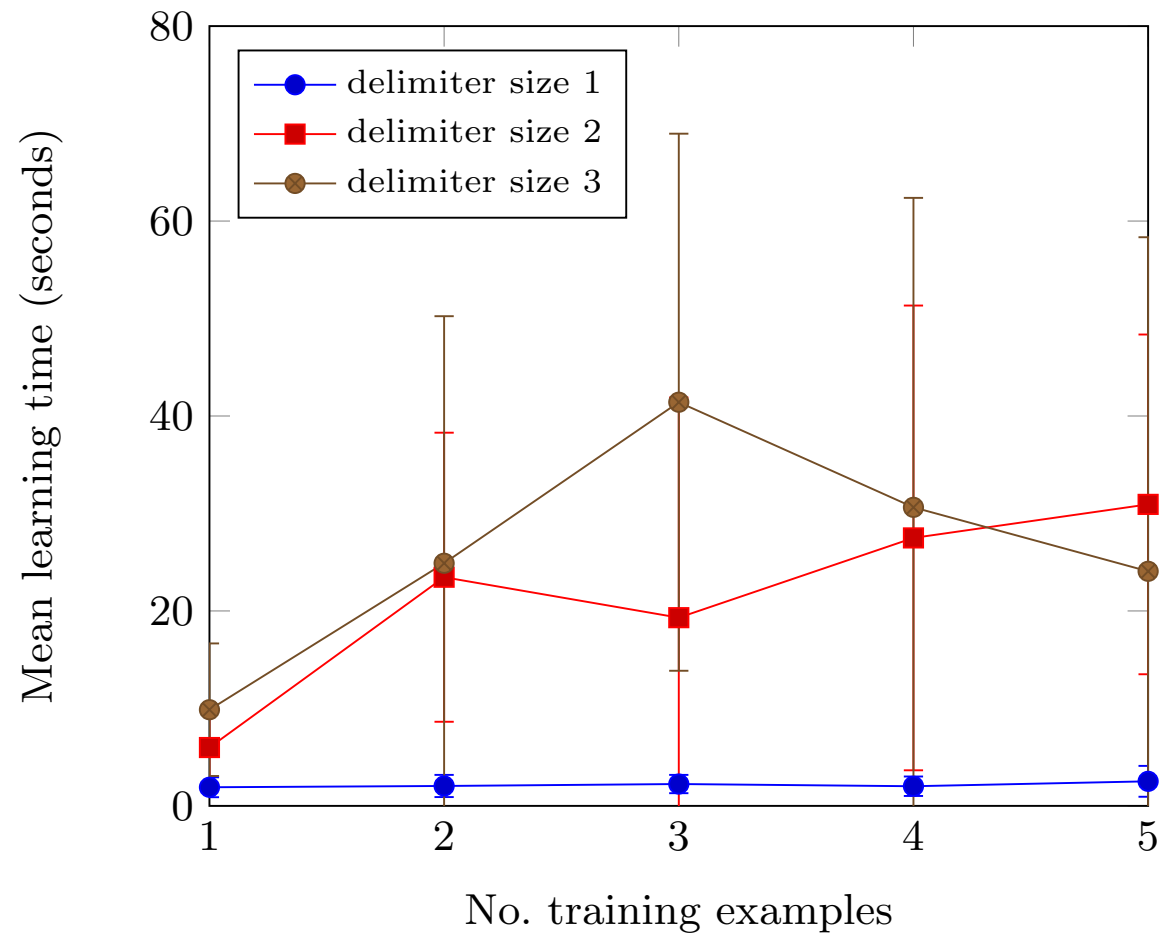
**BK**

```
find_species(A,B):-  
    known_species(Species),  
    find_sublist(A,B,Species).  
known_species([L,o,r,i,c,e,r,a, ,p,i,l,i,c,o,r,n,i,s]).  
known_species([H,a,r,p,a,l,u,s, ,r,u,f,i,p,e,s]).
```

## Ecological predictive accuracies [Paper7.2]



## Ecological training times [Paper7.2]



## Ecological Induced Program[Paper7.2]

$f(A,B):- f3(A,C), \text{find\_species}(C,B).$

$f3(A,B):- \text{find\_species}(A,C), f2(C,B).$

$f2(A,B):- \text{closed\_interval}(A,B,[f,o],[o,d]).$

$f3(A,B):- \text{find\_species}(A,C), f1(C,B).$

$f1(A,B):- \text{closed\_interval}(A,B,[e,a],[t,s]).$

## Medical Data Wrangling input [Paper7.2]

P_001	67	year	lung disease: n/a, Diagnosis: Unknown	80.78
P_003	56		Diagnosis: carcinoma, lung disease: unknown	20.78
P_013	70		Diagnosis: pneumonia	55.9

## Output [Paper7.2]

Output

P_001	67	Unknown
P_003	56	carcinoma
P_013	70	pneumonia



## Induced program [Paper7.2]

Induced program

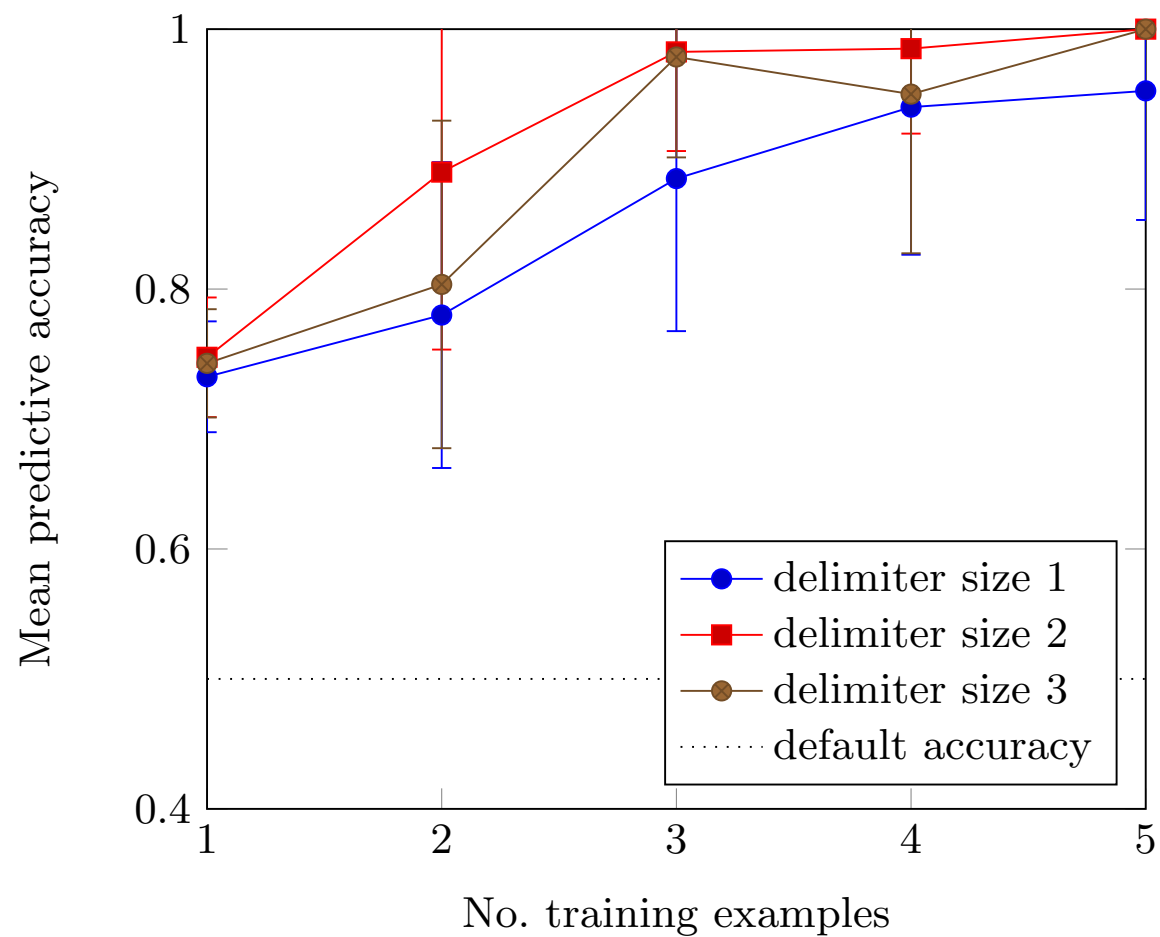
```
f(A,B):- f2(A,C), f1(C,B).
```

```
f2(A,B):- find_patient_id(A,C), find_int(C,B) .
```

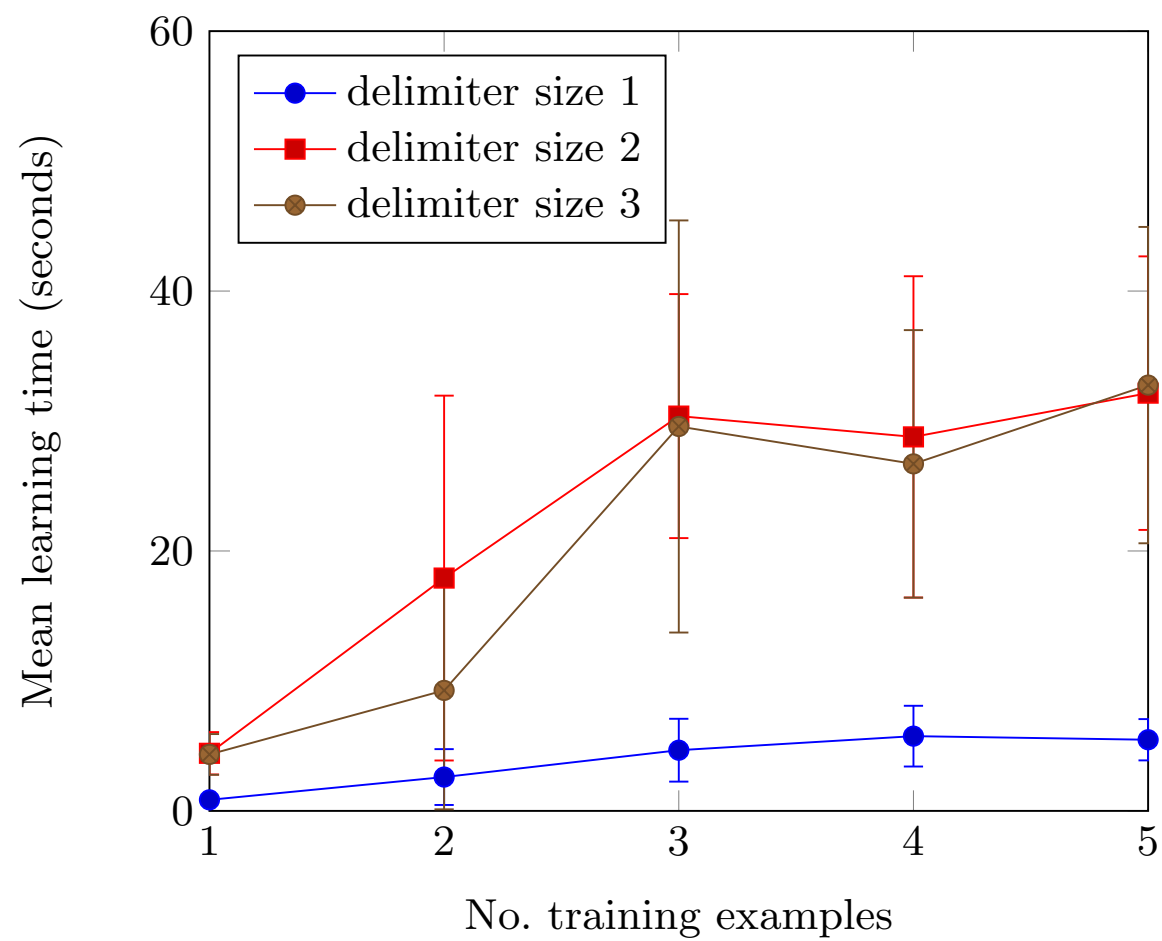
```
f1(A,B):- open_interval(A,B,[':',' '],[';', 'n']).
```

```
f1(A,B):- open_interval(A,B,[':',' '],[';', ' ']).
```

## Medical predictive accuracies [Paper7.2]



## Medical training times [Paper7.2]



## Medical Induced Program[Paper7.2]

```
f(A,B):- f2(A,C), f2(C,B).
```

```
f2(A,B):- find_patient_id(A,C), find_int(C,B).
```

```
f2(A,B):- f1(A,C), find_float(C,B).
```

```
f1(A,B):- open_interval(A,B,[':', ' '],[';', 'n']).
```

```
f1(A,B):- open_interval(A,B,[':', ' '],[';', ' ', ' ']).
```

## Summary

- Data Wrangling - transform raw data for analysis
- First commercial mass market use of IP in 2013
- Microsoft Research Redmond - Inductive Programming
- Academic Research - results dependent on primitives used
- Medical records example - patientID and delimiters
- Ecological records example - speciesID and delimiters
- Induced programs readable - supports debugging