NIH Intramural Research Program
Our Research Changes Lives

SOCcer: Automatic coding of free-text job descriptions to standardized occupation codes

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Overview

- Occupation information
  - Use and collection
  - Standardized classification systems
- SOCcer
  - Framework
  - Performance measures
  - Future advancements and new directions

Occupation Information

Finance, credit, purchase preferences

Medical diagnosis

Surveillance to improve health policy and identify priorities

Primary or confounding factor in **epidemiologic studies**

What is your job title?

- Many ways of describing an occupation
- Different level of detail
- Changes depending on who is asking

Wile E. Coyote
GENIUS
HAVE BRAIN WILL TRAVEL

<u>Standardized Occupation Categories</u>

Mechanical Engineer
Misc. Engineer
Physical Scientist
Chief Executive

Standard Occupational Codes

US SOC 2010

Major group	19-0000	Life, Physical, and Social Science Occupations
Minor Group	19-1000	Life Scientists
Broad Group	19-1040	Medical Scientists
Detailed Occupation	19-1041	Epidemiologists
	19-1042	Medical Scientists, Except Epidemiologists

Major group	29-0000	Healthcare Practitioners and Technical Occupations
Minor Group	29-1000	Health Diagnosing and Treating Practitioners
Broad Group	29-1060	Physicians and Surgeons
Detailed Occupation	29-1062	Family and General Practitioners
	29-1063	General Internist
	29-1069	Physicians and Surgeons, All Other

Occupation in population-based studies

- Current job, longest job, usual job, all jobs
- Wide variety of occupations, industries
- Open-ended questions:
  - What was your job title?
  - What were your main tasks and activities in this job?
  - Who was your employer?
  - What services were provided or what products were made by your employer?
  - Start year/stop year
- Coded to standardized occupation and industry classification systems: SOC and SIC

Coding: time-consuming, modestly reliable

- Manual process
- Based on limited information
- No gold standard
- Agreement between 2 coders is poor/moderate (Koeman et al. 2013)
  - 5-digit level ISCO68 agreement: 36%
  - 3-digit level ISCO68 agreement: 55%
- Preferably independent assignments by 2 coders, resolve discordant assignments
- Costly in large-scale studies

Multiple recent efforts to automate

- NIOSH: http://wwwn.cdc.gov/niosh-nioccs/
- U. Montreal: www.caps-canada.ca
- Burstyn et al. (2014) Beyond crosswalks: reliability of exposure assessment following automated coding of free-text job descriptions for occupational epidemiology.
- Patel et al. (2012) Performance of automated and manual coding systems for occupational data: A case study of historical records

- Batch vs. job-by-job.
- Most require the user to make the final determination from multiple choices or do not provide an assignment when low confidence/no match.
- Different coding schemes.

Objective

- Develop a computer algorithm to assign standardized occupation classifications (SOC) based on free-text responses.
  - Reduce but not replace expert coding

- Cross-NIH institute collaboration with Division of Computational Bioscience
  - Expertise in natural language processing and classification

Our framework

- Adaptable system
  - [Initially] Code to US SOC 2010
    - Electronic knowledge base of job titles and tasks for each SOC (O*NET)
  - [Future] Other classification systems
- Assumption: Better matches by using multiple aspects of job description
  - Job title, tasks, coded industry

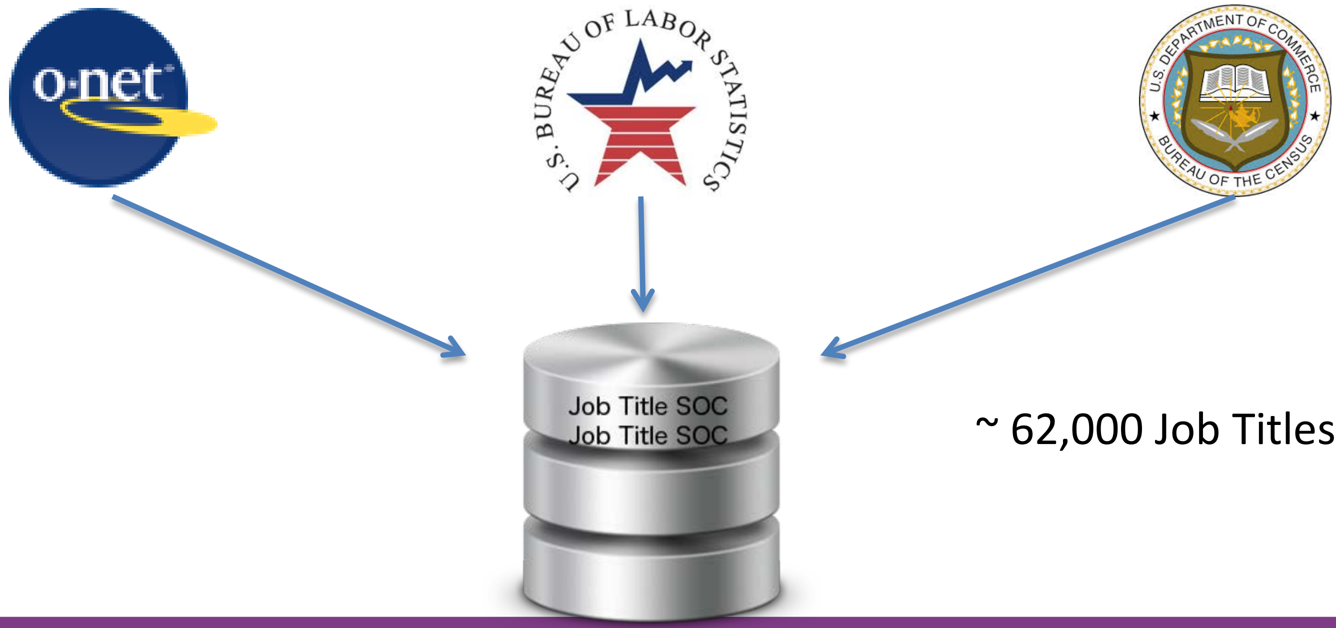
SOCcer

Standardized Occupation Coding for Computer-assisted
Epidemiological Research

http://soccer.nci.nih.gov

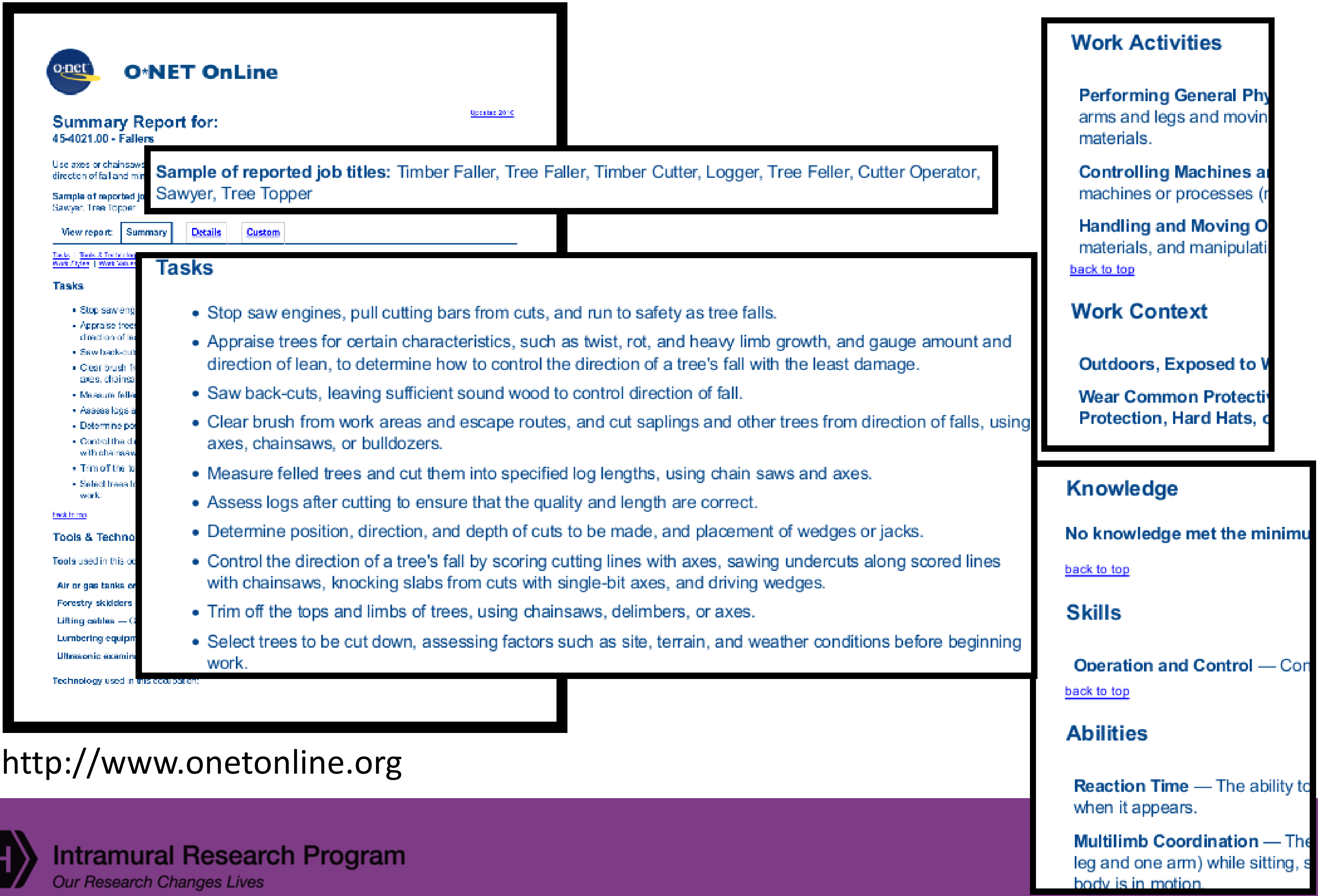
Knowledge Base Development

Data Sources		
Production database of job titles Crosswalk information	Direct Match Title File	U.S. Census Occupational Index



~ 62,000 Job Titles

O*NET for US SOC 2010



O*NET OnLine

Updated 2010

Summary Report for:
45-4021.00 - Fallers

Use axes or chainsaws … direction of fall and mi…

Sample of reported jo… Sawyer, Tree Topper

View report: Summary | Details | Custom

Tasks | Tools & Technology … Work Styles | Work Values …

Sample of reported job titles: Timber Faller, Tree Faller, Timber Cutter, Logger, Tree Feller, Cutter Operator, Sawyer, Tree Topper

Tasks

- Stop saw engines, pull cutting bars from cuts, and run to safety as tree falls.
- Appraise trees for certain characteristics, such as twist, rot, and heavy limb growth, and gauge amount and direction of lean, to determine how to control the direction of a tree's fall with the least damage.
- Saw back-cuts, leaving sufficient sound wood to control direction of fall.
- Clear brush from work areas and escape routes, and cut saplings and other trees from direction of falls, using axes, chainsaws, or bulldozers.
- Measure felled trees and cut them into specified log lengths, using chain saws and axes.
- Assess logs after cutting to ensure that the quality and length are correct.
- Determine position, direction, and depth of cuts to be made, and placement of wedges or jacks.
- Control the direction of a tree's fall by scoring cutting lines with axes, sawing undercuts along scored lines with chainsaws, knocking slabs from cuts with single-bit axes, and driving wedges.
- Trim off the tops and limbs of trees, using chainsaws, delimbers, or axes.
- Select trees to be cut down, assessing factors such as site, terrain, and weather conditions before beginning work.

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Tools & Techno…

Tools used in this oc…

Air or gas tanks or…
Forestry skidders …
Lifting cables — C…
Lumbering equipm…
Ultrasonic examin…

Technology used in this occupation:

Work Activities

Performing General Phy… arms and legs and movin… materials.

Controlling Machines a… machines or processes (r…

Handling and Moving O… materials, and manipulati…

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Work Context

Outdoors, Exposed to W…

Wear Common Protecti… Protection, Hard Hats, o…

Knowledge

No knowledge met the minimu…

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Skills

Operation and Control — Co…

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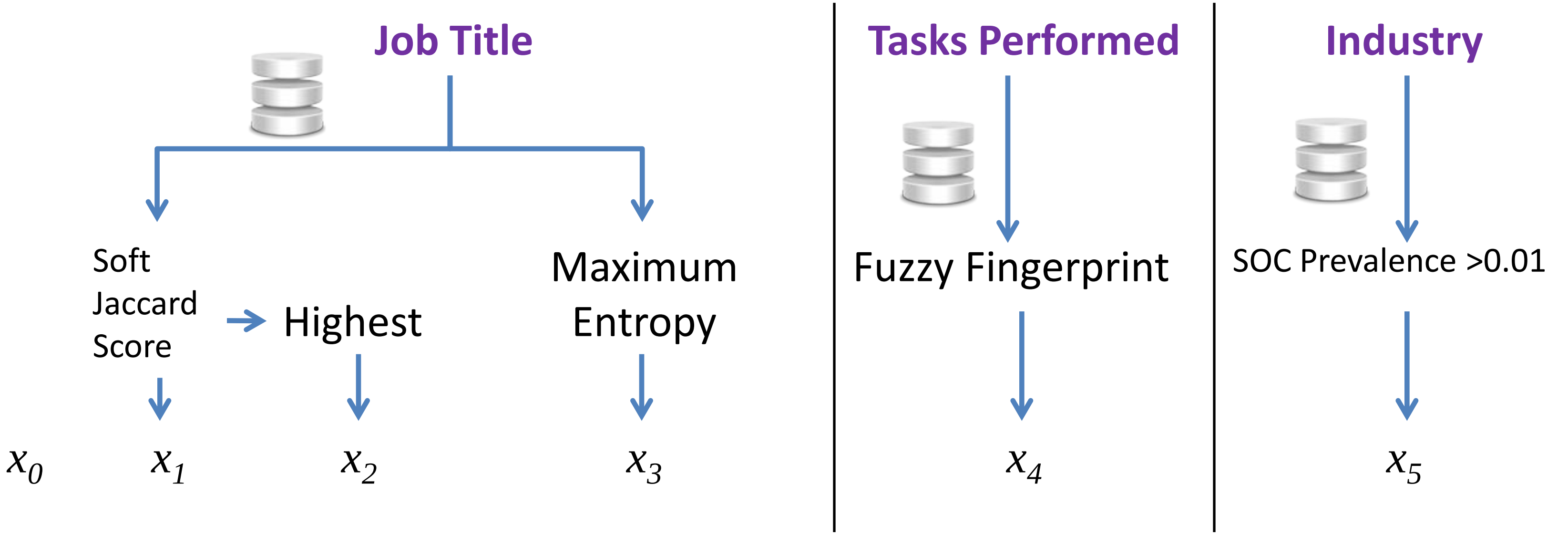
Abilities

Reaction Time — The ability to… when it appears.

Multilimb Coordination — The… leg and one arm) while sitting, s… body is in motion.

http://www.onetonline.org

Overview of SOCcer



Job Title

Soft Jaccard Score → Highest

Maximum Entropy

Tasks Performed

Fuzzy Fingerprint

Industry

SOC Prevalence >0.01

x_0 x_1 x_2 x_3 x_4 x_5

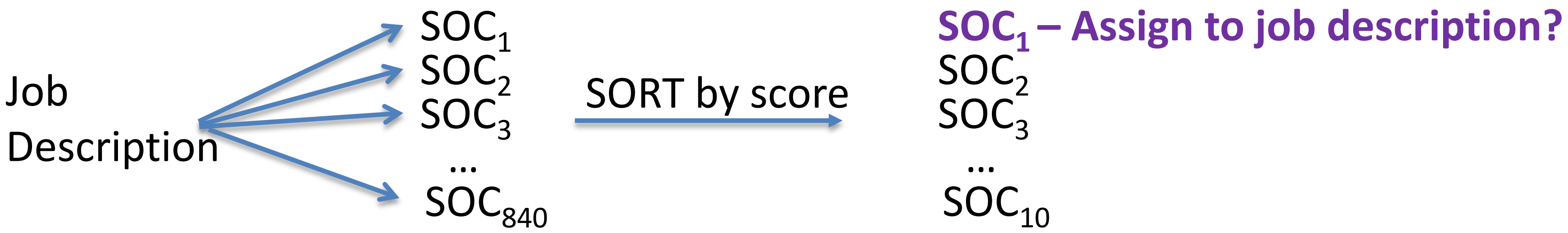
Logistic Regression to obtain score

$$\ln\left(\frac{p}{1-p}\right) = f(\mathbf{x}) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5$$

SOCcer score and SOC code assignment

Algorithm score:
probability that an expert
coder would assign that code

SOCcer output:
Top 10 scoring SOCs



Job Description

SOC_1
SOC_2
SOC_3
…
SOC_{840}

SORT by score

SOC_1 – Assign to job description?
SOC_2
SOC_3
…
SOC_{10}

SOCcer's performance

Validity assessments at 6-digit level:

“Gold standard”: Consensus **expert** SOC assignment

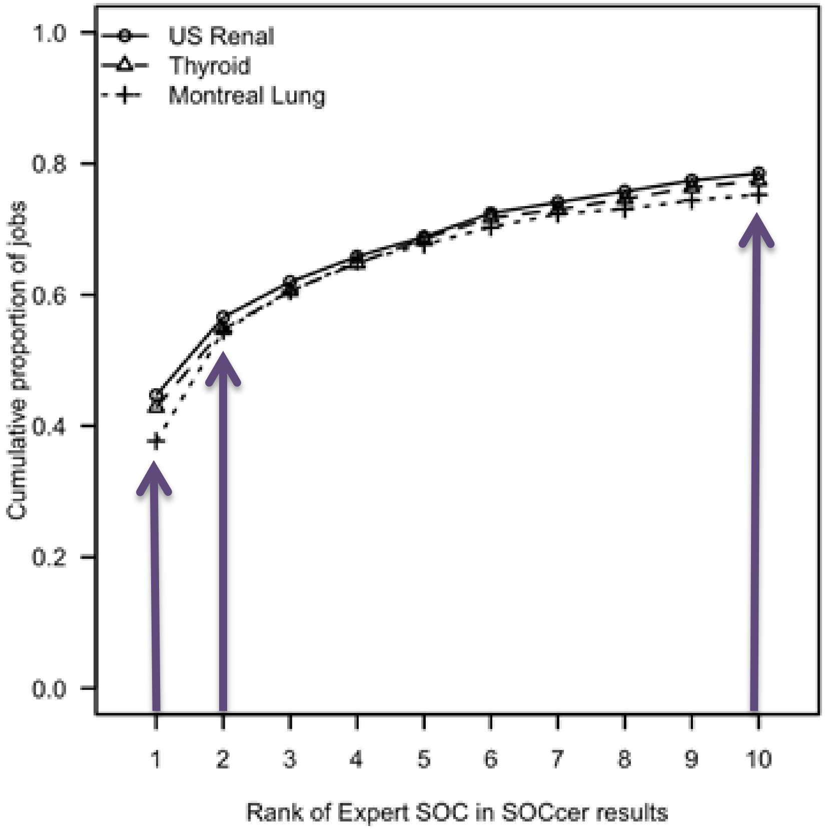
Vs. **Highest scoring SOC-2010 code** from SOCcer

Overall agreement

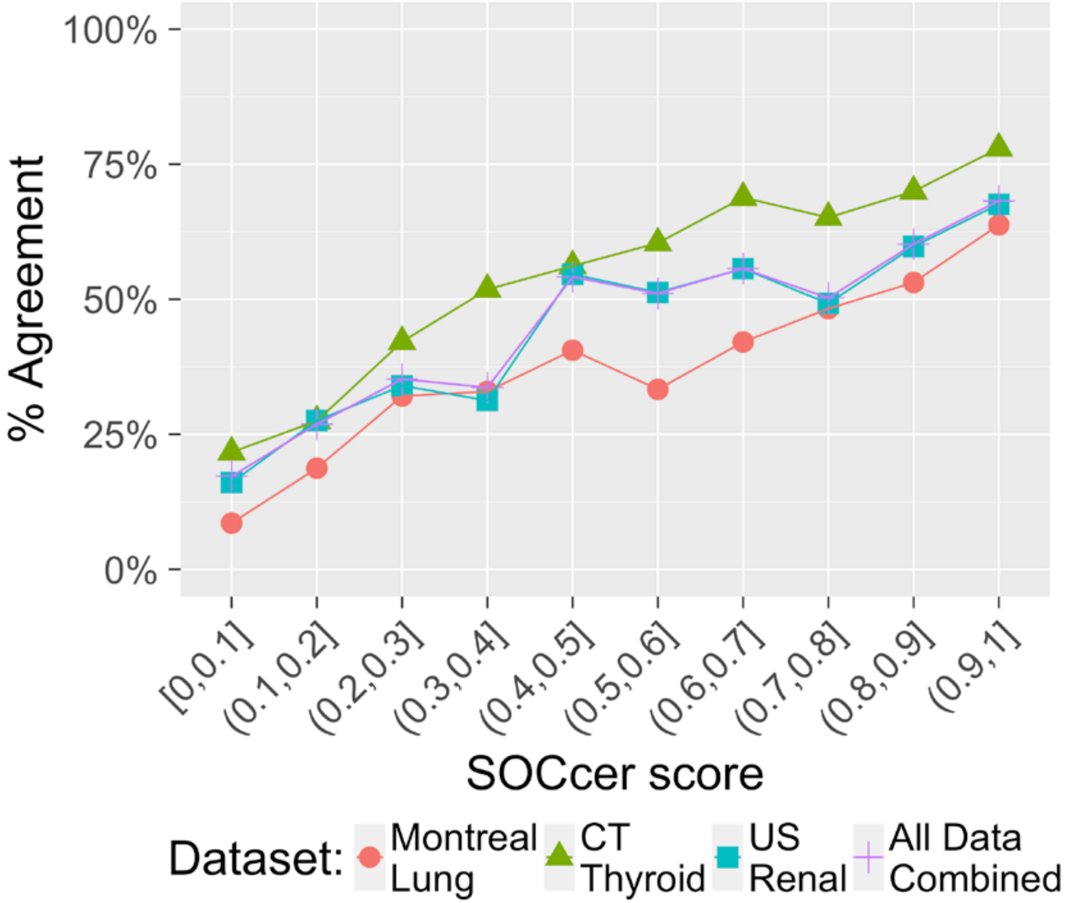
Study	# Jobs	Percent Agreement at SOC Level				Median SOCcer score (IQR)
		2-Digit	3-Digit	5-Digit	6-Digit	
US Renal	11,943	77	64	52	45	0.46 (0.24-0.77)
CT Thyroid	1,942	73	59	50	44	0.22 (0.08-0.51)
Montreal Lung	829	74	56	46	38	0.45 (0.22-0.79)
Combined	**14,519**	**76**	**63**	**51**	**41**	**0.44 (0.23-0.75)**

	Coder vs. Coder	Computer vs. Coders		
	Koeman	Burstyn	Patel (NIOSH)	US Renal
- 3-digit	55%	31-85%	63%	63%
- 5-digit	36%	9-72%	52%	51%

Did the expert assigned code appear in any of the top 10 codes from SOCcer?

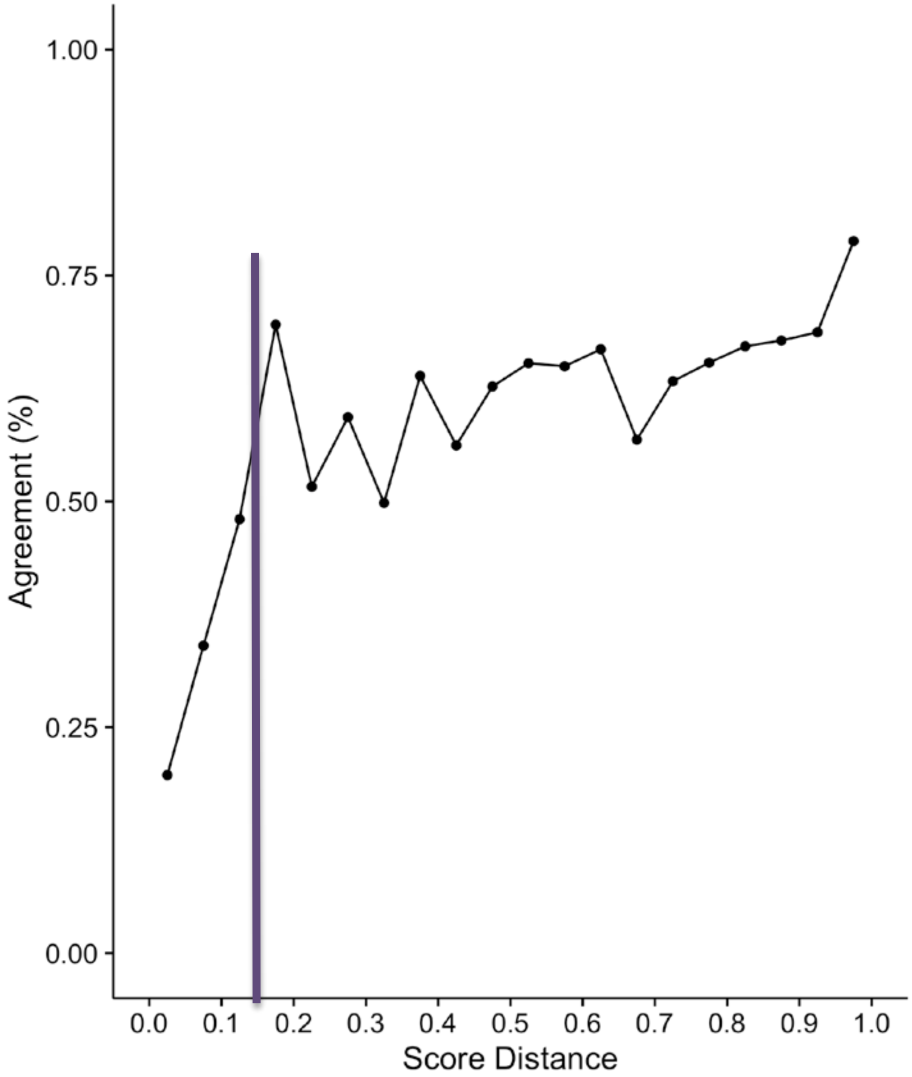


Agreement by score



Agreement by score distance to 2nd ranked SOC code:

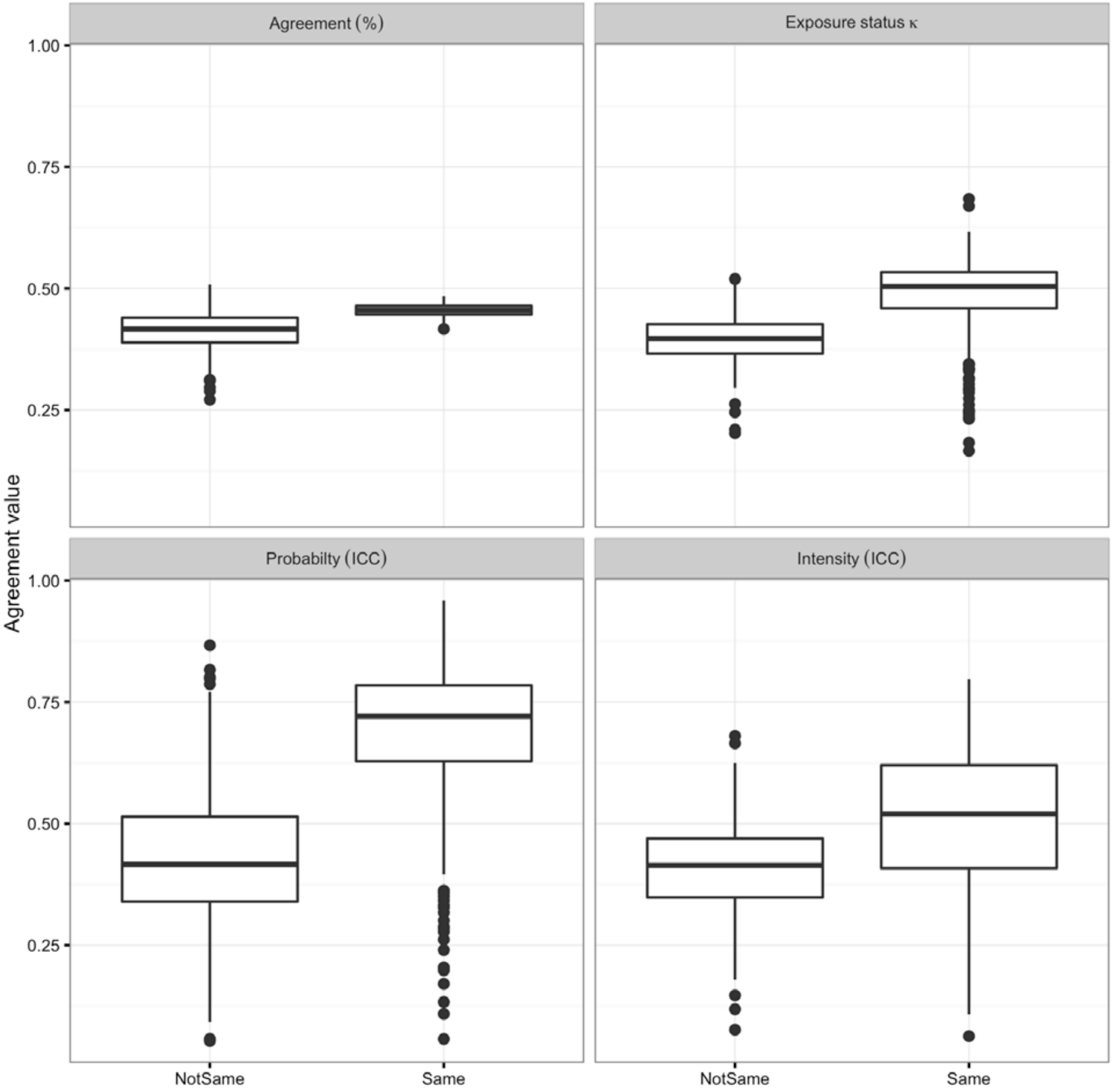
Score distance = $\text{score}_1 - \text{score}_2$



Do the mis-assignments matter?

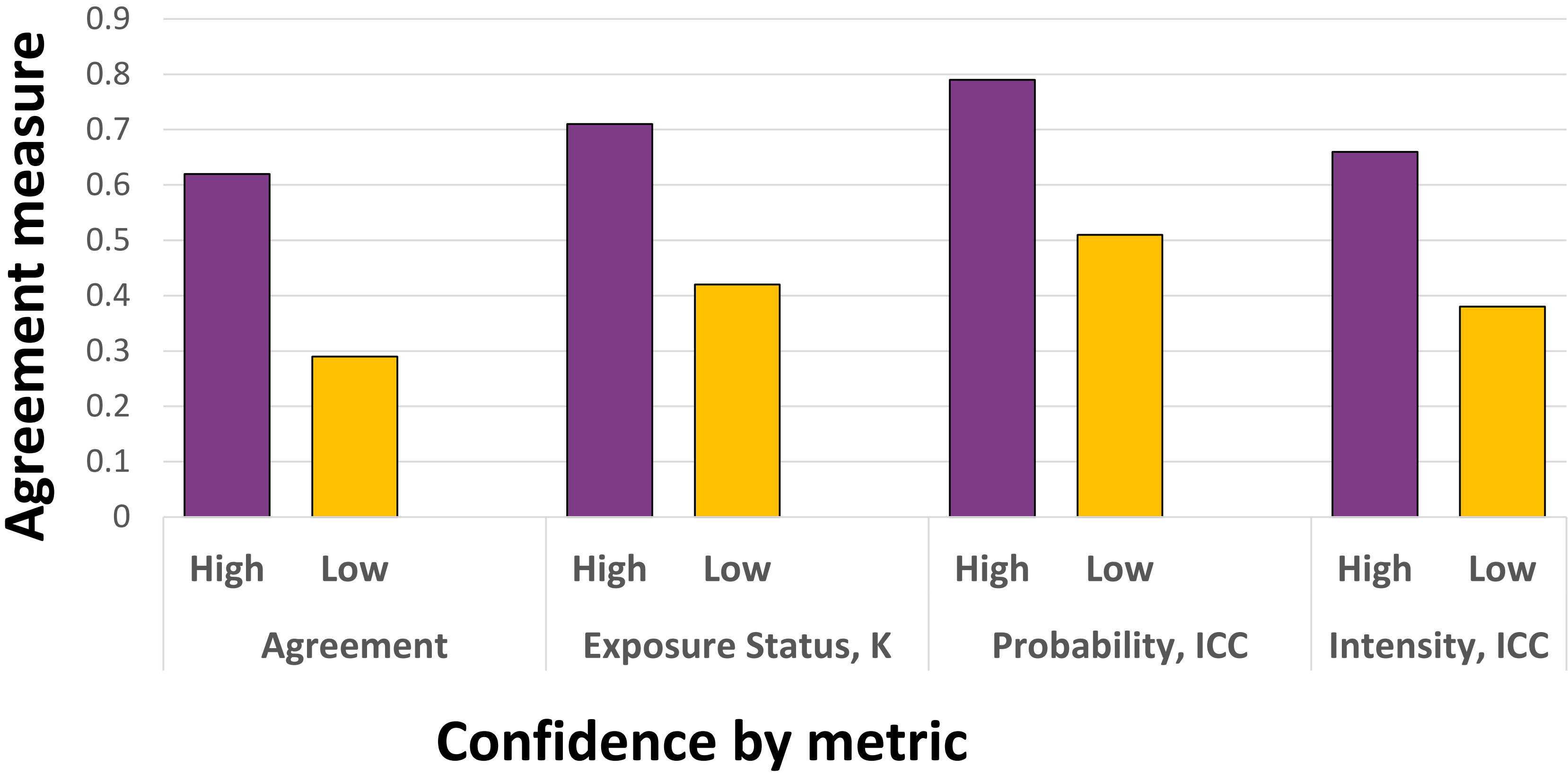
- Generic codes may be difficult to correctly code, but may result in same exposure estimate (e.g., welder)
- Linked expert & highest scoring SOC code to CANJEM
- Compared agreement in exposure estimates
  - Generally similar patterns to SOC code
  - Median kappa on exposed/not exposed: 0.56 (IQR 0.52-0.58)
  - Median ICC on continuous probability metric: 0.66 (IQR 0.58-0.73)
  - Median ICC on continuous probability metric: 0.50 (IQR 0.44-0.56)

Did the top 2 ranked SOC codes assign the same exposure?

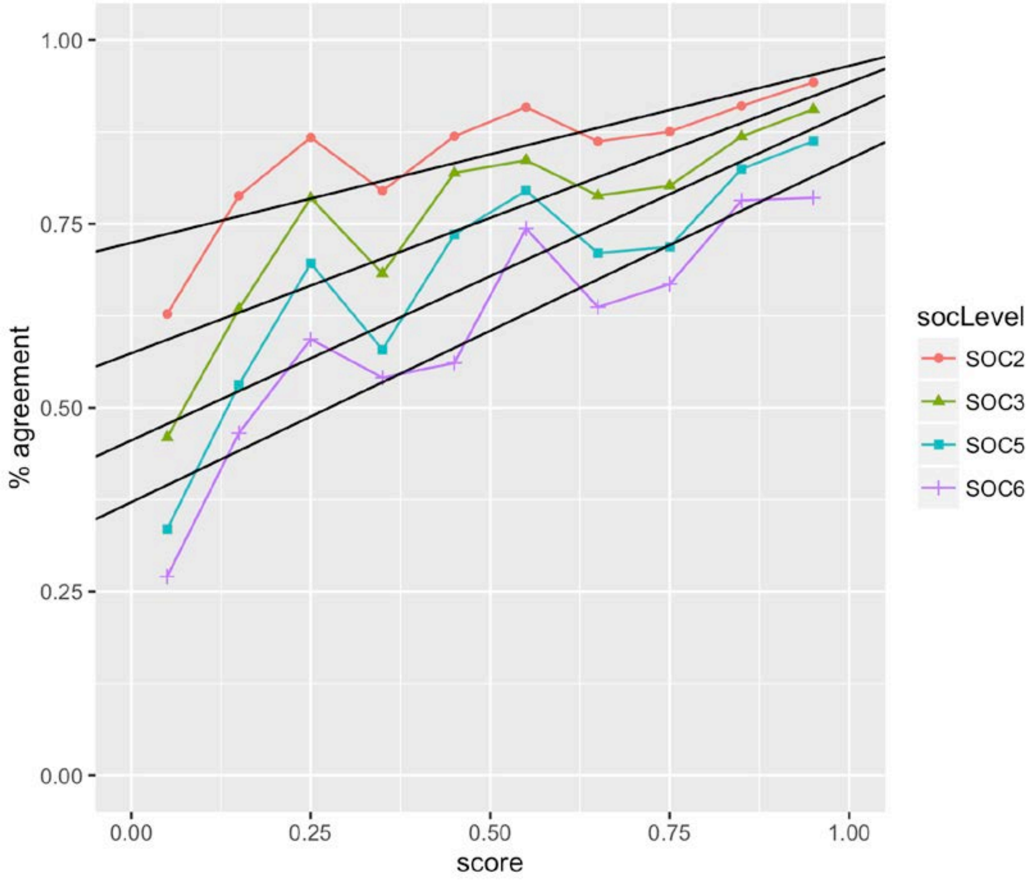


Agreement by confidence in assignment

HIGH: score ≥0.3 *and* score$_{1\text{-}2}$ ≥0.15



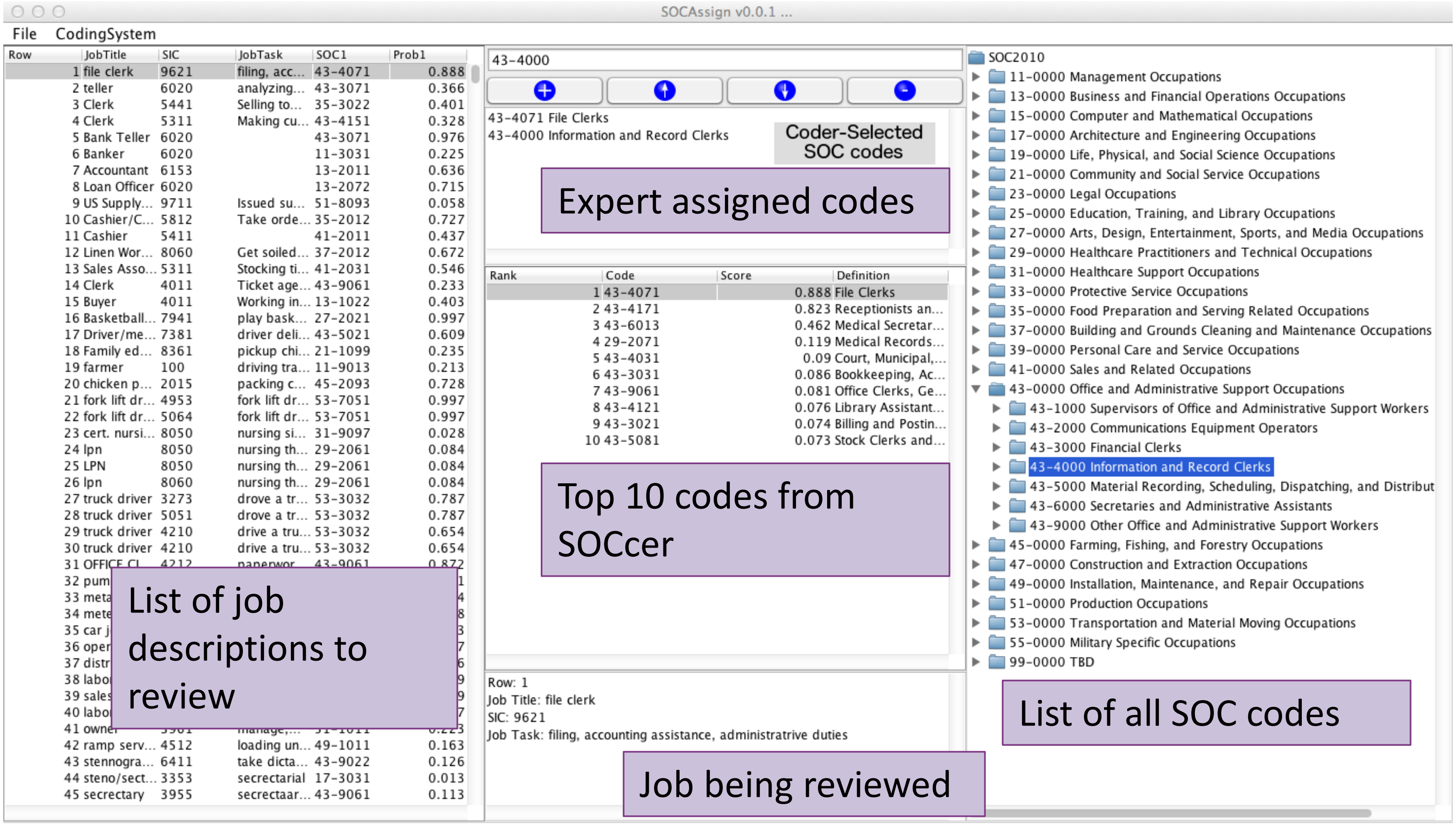
Agreement at varying hierarchy levels



Main findings

- Can reduce expert coding task
- Detailed coding not always possible (data quality)
- 6-digit level
  - Manual coding necessary for nontrivial # of jobs
  - Score and JEM-based metrics to prioritize expert assessment
- 3-digit level
  - Excellent overall agreement and at scores ≥0.25

SOCAssign: Companion Software



Row	JobTitle	SIC	JobTask	SOC1	Prob1
1	file clerk	9621	filing, acc...	43-4071	0.888
2	teller	6020	analyzing...	43-3071	0.366
3	Clerk	5441	Selling to...	35-3022	0.401
4	Clerk	5311	Making cu...	43-4151	0.328
5	Bank Teller	6020		43-3071	0.976
6	Banker	6020		11-3031	0.225
7	Accountant	6153		13-2011	0.636
8	Loan Officer	6020		13-2072	0.715
9	US Supply...	9711	Issued su...	51-8093	0.058
10	Cashier/C...	5812	Take orde...	35-2012	0.727
11	Cashier	5411		41-2011	0.437
12	Linen Wor...	8060	Get soiled...	37-2012	0.672
13	Sales Asso...	5311	Stocking ti...	41-2031	0.546
14	Clerk	4011	Ticket age...	43-9061	0.233
15	Buyer	4011	Working in...	13-1022	0.403
16	Basketball...	7941	play bask...	27-2021	0.997
17	Driver/me...	7381	driver deli...	43-5021	0.609
18	Family ed...	8361	pickup chi...	21-1099	0.235
19	farmer	100	driving tra...	11-9013	0.213
20	chicken p...	2015	packing c...	45-2093	0.728
21	fork lift dr...	4953	fork lift dr...	53-7051	0.997
22	fork lift dr...	5064	fork lift dr...	53-7051	0.997
23	cert. nursi...	8050	nursing si...	31-9097	0.028
24	lpn	8050	nursing th...	29-2061	0.084
25	LPN	8050	nursing th...	29-2061	0.084
26	lpn	8060	nursing th...	29-2061	0.084
27	truck driver	3273	drove a tr...	53-3032	0.787
28	truck driver	5051	drove a tr...	53-3032	0.787
29	truck driver	4210	drive a tru...	53-3032	0.654
30	truck driver	4210	drive a tru...	53-3032	0.654
31	OFFICE CL...	4212	paperwor...	43-9061	0.872
32	pum				1
33	meta				4
34	mete				8
35	car j				3
36	oper				7
37	distr				6
38	labo				9
39	sales				9
40	labo				7
41	owner		manage,...		0.223
42	ramp serv...	4512	loading un...	49-1011	0.163
43	stennogra...	6411	take dicta...	43-9022	0.126
44	steno/sect...	3353	secrectarial	17-3031	0.013
45	secrectary	3955	secrectaar...	43-9061	0.113

List of job descriptions to review

43-4000

43-4071 File Clerks
43-4000 Information and Record Clerks

Coder-Selected SOC codes

Expert assigned codes

Rank	Code	Score	Definition
1	43-4071	0.888	File Clerks
2	43-4171	0.823	Receptionists an...
3	43-6013	0.462	Medical Secretar...
4	29-2071	0.119	Medical Records...
5	43-4031	0.09	Court, Municipal,...
6	43-3031	0.086	Bookkeeping, Ac...
7	43-9061	0.081	Office Clerks, Ge...
8	43-4121	0.076	Library Assistant...
9	43-3021	0.074	Billing and Postin...
10	43-5081	0.073	Stock Clerks and...

Top 10 codes from SOCcer

Row: 1
Job Title: file clerk
SIC: 9621
Job Task: filing, accounting assistance, administratrive duties

Job being reviewed

- SOC2010
  - 11-0000 Management Occupations
  - 13-0000 Business and Financial Operations Occupations
  - 15-0000 Computer and Mathematical Occupations
  - 17-0000 Architecture and Engineering Occupations
  - 19-0000 Life, Physical, and Social Science Occupations
  - 21-0000 Community and Social Service Occupations
  - 23-0000 Legal Occupations
  - 25-0000 Education, Training, and Library Occupations
  - 27-0000 Arts, Design, Entertainment, Sports, and Media Occupations
  - 29-0000 Healthcare Practitioners and Technical Occupations
  - 31-0000 Healthcare Support Occupations
  - 33-0000 Protective Service Occupations
  - 35-0000 Food Preparation and Serving Related Occupations
  - 37-0000 Building and Grounds Cleaning and Maintenance Occupations
  - 39-0000 Personal Care and Service Occupations
  - 41-0000 Sales and Related Occupations
  - 43-0000 Office and Administrative Support Occupations
    - 43-1000 Supervisors of Office and Administrative Support Workers
    - 43-2000 Communications Equipment Operators
    - 43-3000 Financial Clerks
    - 43-4000 Information and Record Clerks
    - 43-5000 Material Recording, Scheduling, Dispatching, and Distribut
    - 43-6000 Secretaries and Administrative Assistants
    - 43-9000 Other Office and Administrative Support Workers
  - 45-0000 Farming, Fishing, and Forestry Occupations
  - 47-0000 Construction and Extraction Occupations
  - 49-0000 Installation, Maintenance, and Repair Occupations
  - 51-0000 Production Occupations
  - 53-0000 Transportation and Material Moving Occupations
  - 55-0000 Military Specific Occupations
  - 99-0000 TBD

List of all SOC codes

Preview of future advancements

- **SOCcer 1.1**
  - Expand training data to include job descriptions from epidemiologic studies and retrain algorithm
  - Increases **overall** 6-digit agreement to **>50%**
  - March-April 2017
- **SOCcer 2.0**
  - Add and refine classifiers and add training data
  - Increases **overall** 6-digit agreement to **~60%**
  - Late 2017
- **Consider more than one plausible code?**

Expansion to other systems?

- **Requires training data in target system**
  - Previously coded job descriptions
  - O*NET equivalent data source
  - Crosswalk to US SOC 2010
- **Canadian system?**
  - Current and previous versions
  - English & French?

Thank you

- *Expert coders*
  - Susan Viet, Pabitra Josse, Sarah Locke
- *CANJEM*
  - Jerome Lavoue, Thomas Remen
- *Epidemiologic studies*
  - Connecticut Thyroid Study
  - Montreal Lung Cancer Study
  - NCI-SEER NHL Study
  - New England Bladder Cancer Study
  - US Renal Cell Cancer Study