Occupational Skills Mapping for 24/7 AI Career Cyber-coaching

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Overview

- Occupational Skills Mapping for 24/7 AI Career Cyber-coaching
  - Team
  - Project overview and goals
  - Stakeholder analysis
- Occupation and Skills Data
  - O*NET and Bureau of Labor and Statistics
- Analysis and Visualization Plans
- Occupation and Skills Mapping Results
- Next Steps for 2022-2023
Current Team

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Overview

Occupational Skills Mapping for 24/7 AI Career Cyber-coaching is apart of the larger Embedded System Security (ESS) / Trusted AI program within the larger SCALE (Scalable Asymmetric Lifecycle Engagement) network.

SCALE is the preeminent U.S. program for semiconductor workforce development in the defense sector. SCALE provides unique courses, mentoring, internship matching and targeted research projects for college students interested in microelectronics at Purdue University, Notre Dame University and Indiana University.

The Trusted AI program addresses the strategic need to for a systematic test and evaluation framework for AI, which is broken down into four hard problems: Human Trust of AI/ML, Measures, Metrics, and Testing, Data Source Bias and Modularity, Cybersecurity & Risk Modeling.
Goals

• Workers, career coaches, and employment agencies need actionable insights on the evolving labor market
  – Global understanding of occupations and skills outlooks, employment risks
  – Local, actionable data and resources

• Develop occupation and skills maps that can be used as part of career counseling services to guide workers in response to regional and national labor market trends, supply chain issues, or pandemics.

• Focus on strategic areas of needs…
  – Microelectronic and packaging engineering, embedded systems/system on a chip (soc), supply chains.
Existing Tools in this Space

- BLS Publications and Data
- BLS Tools
  - Career OneStop
    - Get My Future
    - My Skills, My Future
  - O*NET
    - My Next Move
- Industry developed
Stakeholder Interviews

We interviewed 7 stakeholders for our project, including:

- Radiation Effects and Systems Engineers PIs at NRL & NSWC Crane
- Recruiter NSWC Crane
- Education and workforce development leadership in DoD and DoE
- Electronic Parts Manager for NASA
Stakeholder Interview Insights

- Defense dept strategic research organizations and administration
  - Overlap with DoE and NASA
- Current and future skill requirements for micro-electronics engineers
  - Skills, abilities and knowledge
- Relationships between government and industrial base
- Challenges of new hires in the workforce
- Recruiting and hiring processes for government agencies
  - Current and future needs
  - Strategic pipeline with national coordination, regional execution
- Challenges of hiring managers
Emerging Challenges

• Micro electronics and packaging engineer positions require extensive education, continuous training
  • Unlikely to be impacted negatively by automation, AI, robotics.
• Strategic need is now. Recruiting pipelines exist but have challenges with getting US citizen interest.
• Challenges begin at identifying and capturing interests of HS through undergraduate and graduate school.
• Graduates/new entrants have challenge of navigating government and industry without insider knowledge
Data

Census
- **NAICS** - industrial codes standard that links industry statistics with occupation employment projections.

BLS
- **OCC** – Occupational Classification Standard
- **O*NET** – Detailed occupation profiles with controlled vocabularies.
  - Job tasks, skills, abilities, knowledge, certifications and licensing, personalities
- **Occupational Employment and Wage Statistics Survey**
- **Current Employment Statistics** – Industry and regional employment figures
- **Occupation Employment Projections** – 10 year employment projection for industries and occupations
- **Injuries and Illnesses** – Statistics on workplace injuries by industry and occupation

Burning Glass Jobs Data
- **Current job listings and advertisements** - Job titles and text description, locations, posting dates
Data

Challenges

• Data on impacts of automation, robotics, and AI technologies on workforce is not collected by BLS.
• Need to link national standards (NAICS, OCC) with job titles and descriptions
  • Semantic level comparisons of job titles and descriptions – same meaning but different words.
  • Conceptual fuzziness between skills, abilities, and job tasks
• Strategic-need jobs and skills are novel
  • No clear education programs and pathways
  • Unique, hard to title and describe
  • Institutional knowledge, industry knowledge
• Seasonality vs non-seasonal jobs
Data

Opportunities

• Develop proximal measures of risk and strategic needs
  • Current employment, employment projections, injuries/illness/fatalities, job postings, skill commonality/rarity, salary
  • Industry, national and regional projections
• NLP data preparation methods that allow differentiation of skills, abilities and tasks found in job descriptions.
• Job title and occupational classification matching and industry
  • Fuzzy matching of occupation titles and current job titles from advertisements.
Data Analysis

• Occupation and skill multi-edge networks
  • Hierarchal network – industry, job families, occupations, job titles
  • Undirected, bimodal adjacency networks
• Risk Measure associated with skills and occupations
  • Skill risk to automation, AI/ML, robots
  • BLS Occupation projects for employment opportunities
• Strategic Need Score for skills and occupations
  • Skill demand and associated income ranges
  • Essential skill – common skills associated with many occupations
• Employment Opportunity in Job listings
Visualization Plan

• Occupation and skills network maps
  • Interactions – filtering, zooming, details on demand
  • Map features updated based user’s interests and values
    • Education, salary, risk scores, skill, etc.
  • Career pathway overlays
• Regional geospatial maps
  • Current and projected occupational employment
  • Educational opportunities
• Occupation profiles
  • Describe occupation in detail.
  • Similar occupations
  • Temporal trends for salary, occupation projects, risk
Occupation and skills network analysis

O*Net

Occupations | Skills | Abilities | Knowledge
---|---|---|---

BLS

Statistics

- Employment Totals
  - Current
  - 10 year projections
- Mean wages
  - Hourly
  - Annual
- Industry Profiles
• Selected skill elements to use
• Tested layouts and clustering analysis methods
  • Blondel Community Detection Modularity Algorithm
  • Spin Glass Community Detection Algorithm
  • Filtered edges to include only high value weights

O*Net Occupation and Skills Network V 1.0
Selected skill elements to use

Tested layouts and clustering analysis methods
  - Blondel Community Detection Modularity Algorithm
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O*Net Occupation and Skills Network V 2.0
Self Organizing Map (SOM)

SOM was tested to build map using all of the O*Net data, i.e. maintain complexity of the skills data.

Results highlighted issues with inconsistent occupation-skills ratings in O*NET. The resulting maps had issues with legibility and interpretability.
O*Net Occ. and Skills Network v3.0

This version of the network relies on multistep process to generate the map layout.

1. Use circle pack algorithm to organize nodes based on the Blondel communities identified in the "knowledge" skills subgraph.
2. Apply force atlas algorithm to each Blondel clusters with all skill elements.
3. Occupation nodes are fixed in place, and force atlas algorithm is re-applied to arrange skill elements among settle occupations.

The layout design accounts for the fact that occupations have broad overlap in their skills requirements, and that “Regional, industry maps” are needed supplement an overall map.
O*NETs Knowledge elements are dispersed throughout the network layout. Knowledge elements are situated nearest/within the Blondel communities near occupations requiring this skill. Using knowledge as the first level of organization helps analysts and viewers quickly characterize each occupation cluster in the map, and search for their interests.
The remaining ONET element nodes tend to fall along a central axis within the network, which aligns to the knowledge elements used to organize the overall network.

Spatial positions provided by the Force Atlas algorithm reveal insights about relationship between abilities, skills, and work activities and knowledge clusters.

- Specialization
- Reasoning and expressing ideas
- Memorization & peripheral vision
- Cognitive abilities vs physical abilities
Occupation Skills Map: Skill Elements
Occupation Skills Map: Work Activity Elements
Occupational Cluster 5: Science & Engineering

Occupations: 159 (19.16%)
Skill Elements: 124 (82.78%)

Edges: 3054 (18.82%)

This cluster includes most engineering, physics, chemistry, and computer science and analytics related occupations, including technicians.
Occupational Cluster 1: Customer Service, Sales/Finance, & Managers
Occupations: 125 (15.18%)
Skill Elements: 112 (74.17%)
Edges: 3204 (19.74%)
Occupational Cluster 8: Low Knowledge Req.

Occupations: 196 (23.61%)
Skill Elements: 108 (71.51%)
Edges: 1617 (9.96%)

This cluster has no knowledge elements associated with occupations, and includes most manual labor and machine operators. However, some higher skill occupations are found here that may be better categorized with improved data and filtering.
The US Bureau of Labor Statistics (BLS) releases annual Occupational Employment and Wage Statistics (OEWS) for major occupations tracked by the Dept. of Commerce.

OEWS are measured at US geopolitical units (e.g. states, metropolitan and rural census areas), which we can map!

We have implemented some example choropleth maps using OEWS data for select Microelectronics occupations found in O*NET for midwestern states.

Mapped OEWS measurements includes:
- total employment,
- 2 job concentration measures, and
- mean and median hourly and annual wages.
Computer Hardware Engineers

- Occupation found across much of the Midwest, with the greatest employment found in Ohio and Illinois.
- However, the relative concentration of computer hardware engineers is greatest in Wisconsin.
- For figures on the right, the color scheme is mapped to the average salary (mean & median).
  - Highest salaries found in Illinois and Minnesota.
  - Note: Salary is not measured equally in this data set.
Aerospace Engineering & Operations Technologists and Technicians

- Limited presence in Midwest, with largest concentrations in Indiana and Ohio.
- The average salary range for this occupation is narrow, and so the color current color scale becomes too extreme.
  - Note salary is not measured equally in this data set.
Sales Reps. for Technical and Scientific Products

- Occupation found across much of the Midwest, with the greatest employment found in Ohio, Indiana, Illinois, and Minnesota.
- Indiana and Minnesota have the highest concentration of technical and scientific products sales reps.
- Highest salaries found in Indiana and Michigan using a mean central tendency measure.
Future Development (2022 to 2024)

Y1.Q1 to Y2.Q2

• Implement a visual analytics **Occupation and Skills Map Dashboard** site,
  • Interactive versions of occupations and skills maps
    • Details on demand, filtering, and overlays
    • Visually represent risk scores, salaries, projections data on maps
  • Occupation profiles in three areas: microelectronics packaging, radiation hardening, and supply chain
    • Local employment data to help career coaches, hiring managers, and workforce entrants understand job market risks and opportunities.
  • We will identify and engage career counselors and students in a user study to evaluate how stakeholders use these occupational skills maps and occupational profiles dashboard tools.