Competence Information Fusion: Concepts and Challenges

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Overview

• Background
• An Analysis of the Problem of Unreliability of Competence Information
• Introduction of Information Fusion
• Competence Information Fusion
• Conclusions and Future Work
Background

Competence serves as the basis for:

- Recruitment and selection
- Job descriptions
- Training needs analysis
- Assessment of competencies
- Annual appraisal interviews
- Performance-linked promotion
- Salary increases
- Design of learning programmes
- Purchase of training services and consultancy
- Internal/external programmes of accreditation

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- Amazon, Google,
Background

Standards:

- HR-XML
- IMS RDCEO
- IEEE RCD

Data model

Semantic:

- OWL
- DAML
- KIF

Ontology

Competence

public & private employment services

education

industry
Whether are standards sufficient for sharing competence information?

Different people may interpret the same competence of the same person at the same time differently.

Which interpretation is correct/reliable?
An Analysis of Unreliability of Competence Information

Competence is a latent attribute referring to an actor’s underlying qualities and characteristics that lead to an effective performance (e.g., software development).

There is no systematic method to represent and measure potential competence.
**Competence-associated object**: a task, a job, a role, a course, and a test.

**Performance**: take a course, take an exam, and operate a machine,
**Competence-associated object**: a task, a job, a role, a course, and a test.

**Performance**: take a course, take an exam, and operate a machine.

**Evidence source**: an article, a design, and a response to a questionnaire.
Competence-associated object: a task, a job, a role, a course, and a test.

Performance: take a course, take an exam, and operate a machine

Evidence source: an article, a design, and a response to a questionnaire

Subjective factors: mode, motivation, attitude

Objective factors: object (type and instance), tool (type and instance), environment,
**Competence-associated object:** a task, a job, a role, a course, and a test.

**Performance:** take a course, take an exam, and operate a machine,

**Evidence source:** an article, a design, and a response to a questionnaire

**Evidence record:** a report, a comment, an evaluation, a rating, a recommendation, and a certificate
Factors that influence on the observation, record, evaluation of competences

Subjective factors: mode, motivation, attitude, competences, relation to the owner,

Objective factors: perspective tool, media, format, environment,

Selected evidence sources:

- Competence-associated object: a task, a job, a role, a course, and a test.
- Performance: take a course, take an exam, and operate a machine,
- Evidence source: an article, a design, and a response to a questionnaire
- Evidence record: a report, a comment, an evaluation, a rating, a recommendation, and a certificate
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**Evidence record:** a report, a comment, an evaluation, a rating, a recommendation, and a certificate

**Competence source:** a judgment e.g., John’s proficiency level of software development is “expert” or “6”.
Factors that influence on the interpretation and representation of competences

Subjective factors:
- mode,
- motivation,
- attitude,
- competences,
- relation to the owner,
- bias

Objective factors:
- framework
- criteria
- community
- selected evidences

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Competence source: a judgment e.g., John’s proficiency level of software development is “expert” or “6”.

Individual judgment reliable?

Judgments made by different people consistent?
competence → change → competence
Characteristics of competence information in a competence tracing and management system:

- A large amount
- Complicated relations
- Continuously changing
- More or less unreliable
- Inconsistent
How to produce a competence estimate based on multiple data from multiple sources

- The newest data?
- From a certain type of sources?
- With the highest proficiency level?
- Average mean of competence judgments?
Introduction to Information Fusion

Definitions:

“Theory, techniques, and tools conceived and employed for exploiting the synergy in the information acquired from multiple sources (sensors, databases, information gathered by humans, etc.) such that the resulting decision or action is in some sense better (qualitatively or quantitatively, in terms of accuracy, robustness and etc.) that would be possible if any of these sources were used individually without such synergy exploitation.” [B. Dasarathy]
Introduction to Information Fusion

Humans continually integrate data from our senses to make inferences about the external world

[P.K. Varshney].

Information fusion (or data fusion), as techniques, is relatively new and is multi-disciplinary by essence.

[D.L. Hall]
Wireless Sensor Networks (WSN) is a special type of ad hoc network composed of a large number of nodes equipped with different sensor devices. They are usually small and inexpensive with limited sensing, computation, and communication ability. The information received from a single sensor may or may not be credible and trustworthy. [Akyildiz et al., 2002]
They can constantly monitor the situations of a battlefield. They can detect and track targets of the opposing forces (such as tanks, planes, and missiles). As the operations evolve and new operational plans are prepared, new sensor networks can be deployed anytime if necessary. [Akyildiz et al., 2002]
Pilot
Spy
Soldier
Friendly force

property
identity
intention
threaten

mission

State to be estimate and predict

Target to be traced

Performance

Sign from thermal, visual, infrared, acoustic sensors and radars

Report, analysis, processing results
Pilot
Spy
Soldier
Friendly force

property
identity
intention
threaten

mission

estimate
prediction
Pilot
Spy
Soldier
Friendly force

property
identity
intention
threaten

mission

estimate
prediction
Pilot
Spy
Soldier
Friendly force

property
identity
intention
threaten

mission

estimate
prediction

Gain an improved estimate or prediction
Introduction to Information Fusion

Implementation architecture of a data fusion system [D. Hall]
Introduction to Information Fusion

The application of information fusion in technical systems requires mathematical and heuristic techniques from fields [Hall, 1992; Waltz, 1990; and Varshney, 95]:

- Probability and statistics
- Plausibility theory
- Bayesian decision theory
- Pattern recognition
- Fuzzy logic
- Neural network
- Expert systems
- Cognitive psychology, and
- Decision theory
Introduction to Information Fusion

Advantages of Data Fusion [Waltz and Llinas, 1990]

- **Robustness and reliability**: The system is operational even if one or several sources of information are missing or malfunctioning,

- **Extended coverage in space and time**: The system can detect and trace the dynamic changes of the entities because a variety of distributed sensors can acquire information about the same entity at different times in different places,

- **Improved confidence**: The use of redundant and complementary information increases the certainty,

- **Reduced ambiguity**: More complete information provides better discrimination between available hypotheses,

- Providing a solution to **process vast amount information** for many complicated application systems.
Introduction to Information Fusion

• Information fusion is useful for several objectives such as: detection, recognition, identification, tracking, change detection, and decision making.

• These objectives are encountered in many application domains such as defense, robotics, medicine, space, transportation, law enforcement, homeland security, and weather forecast.

• Education?
Competence Information Fusion

Comparison Learning Networks (LNs) with Wireless Sensor Networks (WSNs)

Similarities:
- The state of the target to be traced cannot be directly measured.
- Individual sources have limited ability. They are prone to failures.
- The information received from a single source may or may not be credible and trustworthy.
- A large amount of information comes from multiple sources. They have complicated relations. They may be inconsistent and even conflict.
- Need to roll-up low-level features to high-level features
- The network can be (re-)adjusted

Differences:
- The targets in WSNs is easier to represent than those in LNs
- The ability of the sources in LNs is changeable
Competence Information Fusion

State: (John.software_development)

Target: John

Task: John recently developed a software

Evidence source: code

Source: Sam

Competence source: “John’s proficiency level of software development is ‘expert’”
John’s proficiency level of software development is ‘expert’

A competence estimate is based on Sam’s judgment

John.SD=expert
John’s proficiency level of software development is “expert”.

Consistence => reinforce
Increase degree of trustworthiness of Sam and his judgment

John's proficiency level of software development is "expert".

Consistence => reinforce
Increase degree of trustworthiness of Sam and his judgment
Competence Information Fusion

John’s proficiency level of software development is “expert”.

Conflict => resolve
If the source is judged ‘unreliable’, the judgment is essentially discarded
Competence Information Fusion

John’s proficiency level of software development is “expert.”

If the judgment is created by a person with a high trustworthiness, it is needed to find out the origin of the clash.

John’S.D=expert

2 year ago

evaluation report

Conflict => resolve

Joseph

John’s proficiency level of software development is “Practitioner”
John’s proficiency level of software development is “expert”.

John’s proficiency level of software development is “Practitioner”.

Conflict => resolve
However, if it is proved that the judgment is created by one who is reliable, obviously something with the belief functions is wrong. It is needed to check whether the pressure to change is higher than the resistance parameter.
Competence Information Fusion

John’s proficiency level of software development is “expert”.

Conflict => resolve
If the pressure to change is increased by new judgments and finally is higher than the resistance parameter, the credibility of the judgments and the sources which were used to develop the previous opinions will be re-checked.

John’s proficiency level of software development is “Practitioner”
John's proficiency level of software development is "expert".

These people work in educational technology.

16% John
32% code
John.software_development
John.SD=expert
85%

Conflict => resolve
If the conflict is because they use different competence frameworks and work in different communities, then distinguish the competences used in different communities and define their relation.

These people work in software engineering.

25-35% Sam
83-94% Joseph

John's proficiency level of software development is "Practitioner".

John.SD=expert
John.SD=practitioner
32% educational technology
85% software engineering
Competence Information Fusion

Conflict => resolve
If it is proved that the new judgments are more reliable, the fusion process results in a revision or an update of the current belief function.

John’s proficiency level of software development is “expert”.

John’s proficiency level of software development is “Practitioner”.

John.SD=practitioner

Confidence level: 85%
What is the estimate/prediction of John’s competence in software development?

It depends on how the competence estimate will be used. (the purpose, context, time, and required accuracy)
Conclusions and Future Work

Conclusions:
• The competence information in LNs may be unreliable and inconsistent
• Information fusion technologies may be a potential technical solution

Future work:
• learn and introduce information fusion
• Launch research with real and simulated data set in learning networks
Thank for your attention!

Questions?