Incremental Improvement and Innovative Changes

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Meaning of research

- The prefix "re-" means again.

- The verb "search" means to examine something very carefully in order to find something out.

- The combination "re-search" means serious study of a subject, which is intended to discover new facts or test new ideas.

- In other words, we search the knowledge space again over again in order to find information about something that we are interested in or need to know about.

Goal of academic research

- We need to obtain applicable and publishable results (Experiment).

- We need to provide insightful explanation to the obtained results (Methodology).

- We need to provide comments or reviews on relations of current problems and methods (Introduction).

Our research space

- The research space that we search for applicable and publishable results is formulated as a graph with two types of nodes and three types of edges.
- J "method" nodes (1 <= j <= J) and D "application" nodes (1 <= d <= D).
- Edge between methods, edge between applications and edge between methods and applications.
- Gray circles denote method nodes and white rectangles denote application nodes.
- H denotes the edge weight for how closeness between two nodes.

Graphical representation of research space
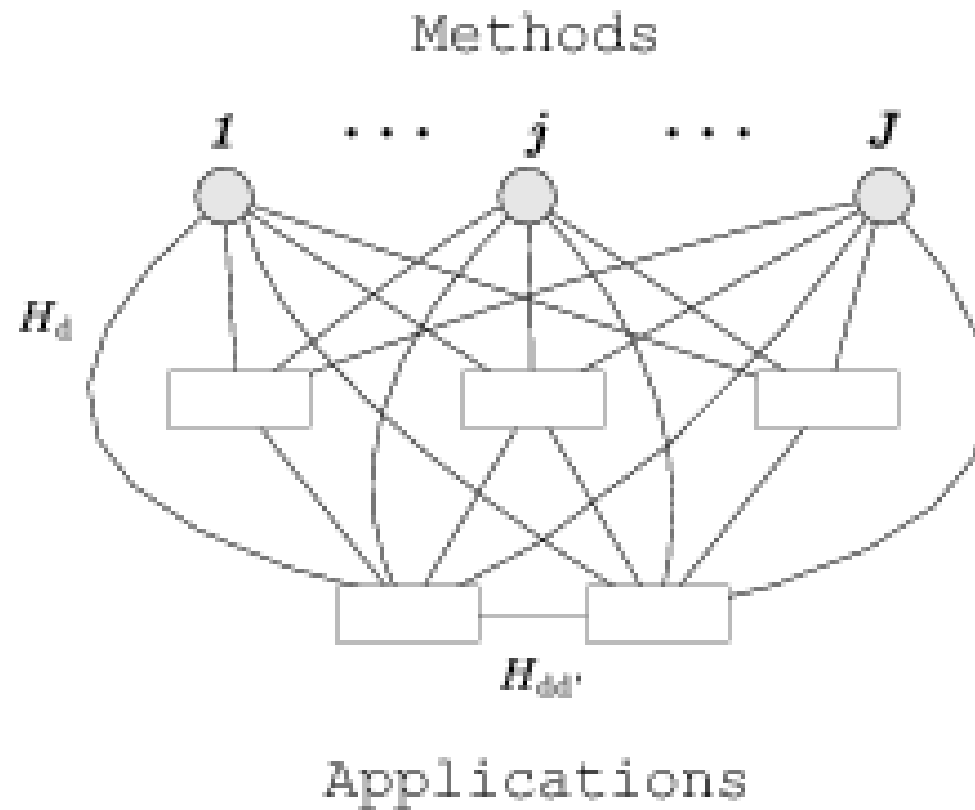
Examples

- Methods: neural networks, evolutionary computation, fuzzy systems, support vector machines, hidden Markov models, Markov random fields …..

- Applications: speech recognition, face recognition, human motion recognition, handwritten Chinese character recognition, human promoter recognition ……

Relational matrix

We define the weight matrix of $\mathcal{G}$ as $\mathbf{A}_{(J+D)\times(J+D)} = [H(e_{xy})]$ and the degree matrix $\mathbf{D} = diag([\sum_y H(e_{xy})])$ for $\mathcal{G}$, where e_{xy} is the edge from the node x to y and $diag(\cdot)$ expands a vector to a diagonal matrix. We compute the Laplacian matrix as $\mathbf{L} = \mathbf{D} - \mathbf{A}$. Note that $\mathbf{L}_{(J+D)\times(J+D)}$ is a sparse, symmetric and positive-definite matrix. By separating topic nodes and document nodes, we convert $\mathbf{L}$ into a block form

$$\mathbf{L} = \begin{bmatrix} \mathbf{L}_{\text{method}} & \mathbf{R} \\ \mathbf{R}^{\mathrm{T}} & \mathbf{L}_{\text{application}} \end{bmatrix}, \tag{1}$$

where the block $\mathbf{L}_{\text{method}}$ encodes edge weights between methods, $\mathbf{R}$ and $\mathbf{R}^{\mathrm{T}}$ represent edge weights between methods and applications, and $\mathbf{L}_{\text{application}}$ contains edge weights between applications.

The sub-matrix R

METHODS AND APPLICATIONS.

	Neural networks	Support vector machines	Manifold learning	Fuzzy systems	. . .
Speech recognition	√	√	?	√	
Handwriting recognition	√	√	?	√	
Face recognition	√	√	√	√	
. . .					

Incremental improvement

- Adding edges.
- Adding edges between methods and applications.
- Adding edges between methods and methods.
- Adding edges between applications and applications.
- Adding three types of edges simultaneously.

Comments

- We are in an incremental improvement age.
- We often slightly improve something to a certain extent.
- Take myself as an example, I adding edge between type-2 fuzzy sets and hidden Markov models, adding edge between Markov random fields and handwritten Chinese character recognition, and adding edge between classifier combination and human promoter recognition.
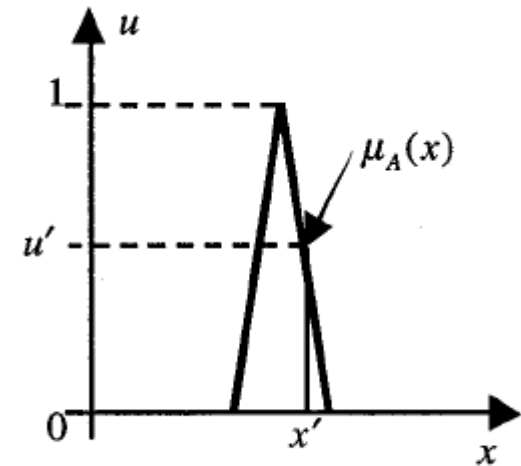
Innovative changes

- We have chance to do a better research other than incremental improvement.

- We can initiate a new application or a new method by adding nodes in research space.

- Why adding nodes is more important than adding edges?

- Because by adding one additional nodes, we potentially create the space for more edges (D + J).

- Indeed, you at least create D + J directions for other researchers.

Comments

- To add a new node (new application or new method), we need to know much about existing nodes, or we shall re-invent the wheel since we may create "new" previously existing nodes.

- New nodes are not really new, which means most of them just change views or combine views of previously existing nodes.

An example

- Jerry Mendel is a famous researcher who initiates "Type-2 fuzzy sets".

- He use a shadow instead of a line to describe the traditional membership function.

- His new views of the existing node really make researchers like me to get new methods for applications.

(a)
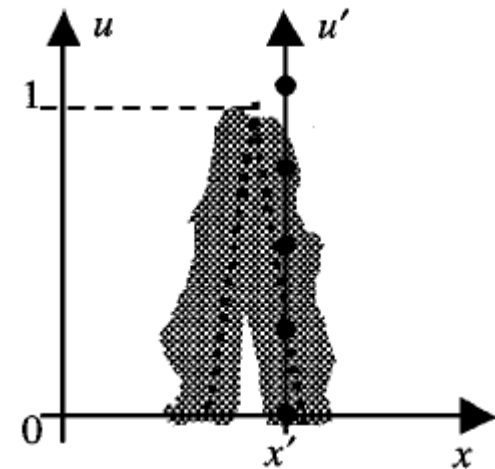
Conclusion

- We search in the research space by adding new edges (incremental improvement) or by adding new nodes (innovative changes).

- We should do both in order to make the research space or graph larger and larger.

- Both are worth doing by our own interests.

- Enjoy research but not survive research ☺

Thank you very much!