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Knowledge Management System development by deploying ART Artificial Neural Networks Algorithm

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ABSTRACT

Application of ART Neural Network Algorithm for Knowledge Management System development is one of its kinds Research Work. This pioneering effort is the fusion of domains such as Knowledge Management (KM) and Artificial Neural Networks. This Research Work is the modular fine-tuning in the existing KM Systems development methodologies. This paper proposes the sure-to-yield-results 'Plasticity-stability' feature of ART Neural Networks in KM System development. The proposed solution is groundbreaking that nullifies many of the disadvantages that prevailing KM system development life-cycle has under its belt.

Keywords: Knowledge Management, Knowledge Assets, Knowledge Walkouts, Tacit Knowledge, Knowledge Artifacts, Knowledge Maps, ART Algorithm – Plasticity and Stability, Organizational Memory.

I. INTRODUCTION

Knowledge can exist and be expressed in many forms, for example: facts, attitudes, opinions, issues, values, theories, reasons, processes, policies, priorities, rules, cases, approaches, models, tools. Methodologies, relationships, risks and probabilities. Ideally people need, not only relevant knowledge but also practical help in applying it and using it to achieve their objectives. Many more companies would benefit from a knowledge management framework that can handle knowledge in a variety of formats and enable people quickly to capture, access, present, understand and exploit pertinent know-how. Early approaches to knowledge management tended to view knowledge as a stock with the emphasis being placed upon knowledge capture and storage. What may be of greater importance in dynamic, fluid and uncertain contexts is the flow of information that allows knowledge to be kept up to date, and new knowledge that is relevant to emerging trends.[1] Knowledge Management is the process of gathering a firm's collective expertise wherever it resides – in databases, on paper, or in people's heads – and distributing it to where it can help produce the biggest payoff [2] As it dawns on many organizations which may be corporations or service providers – that Knowledge is the only competitive asset they have, more of their energies and resources are being directed towards Collaborative Knowledge Harvesting across the enterprise, so that decisions are made swiftly, and wisely by taking stock of the precedents. It is just not sufficing to have Knowledge Assets, but there must be a provision for KM System development, a possible scenario of tapping the most from the precedents so that no time is wasted either in repeating the same grave-mistake or in searching for the Knowledge to pursue the right course of action(s) at all times; across the length and the breath of the organization, not confined by geographical or technological boundaries.

II. METHODS AND MATERIAL

2. Types of Knowledge [3]

Knowledge Type	Description
Domain knowledge	Domain knowledge is valid knowledge for a specified domain. Specialists and experts develop their own domain knowledge and use it for problem solving.
Meta knowledge	Meta knowledge can be defined as knowledge

	about knowledge.
Commonsense knowledge	Commonsense knowledge is a general purpose knowledge expected to be present in every normal human being. Commonsense ideas tend to relate to events within human experience
Heuristic knowledge	Heuristic is a specific rule-of-thumb or argument derived from experience
Explicit knowledge	Explicit knowledge can be easily expressed in words / numbers and shared in the form of data, scientific formulae, product specifications, manuals, and universal principles. It is more formal and systematic.
Tacit knowledge	Tacit knowledge is the knowledge stored in subconscious mind of experts and not easy to document. It is highly personal and hard to formalize, and hence difficult to represent formally in system. Subjective insights, intuitions, emotions, mental models, values and actions are examples of tacit knowledge

2.1 Significance of Tacit Knowledge

Tacit Knowledge has been proven to be mobile and dynamic through knowledge Walkouts. Knowledge Walkout refers to a scenario when a seasoned employee of a particular department or function leaves the organization and joins with a business rival. In this case, that business rival will, as a logical sequence, be benefitted through the ingrained experience of the newly inducted resource (employee). Besides being mobile and dynamic, Tacit Knowledge can have considerable impact on the over-all organizational performance. The most valuable knowledge, skills, and competencies in business reside tacitly between the ears of the employees. As easily as these elements accompany employees home every night, they can also be lured into a competitor's business. Tacit knowledge can rarely be fully articulated, yet it can be easily manifested through application, integration, and collaboration. It can maximize its productive application for both leading, and adapting to turbulent business environments.

2.2 Comparing Tacit Knowledge and Explicit Knowledge [4]

Category	Tacit Knowledge	Explicit Knowledge
Nature	Personal, Context-specific	Can be codified and explicated
Formalization	Difficult to formalize, record, encode, or articulate	Can be codified and transmitted in a systematic and formal language
Development Process	Developed through a process of trial and error encountered in practice	Developed through explication of tacit understanding and interpretation of information
Location	Stored in the minds of people	Stored in documents, databases, Web Pages, emails, etc
Conversion Processes	Converted to explicit through externalization that is often driven by metaphors and analogies	Not required
IT Support	Hard to manage, share, or support with IT	Well supported by the existing IT
Medium needed	Needs a rich communication medium	Can be transferred through conventional electronic channels

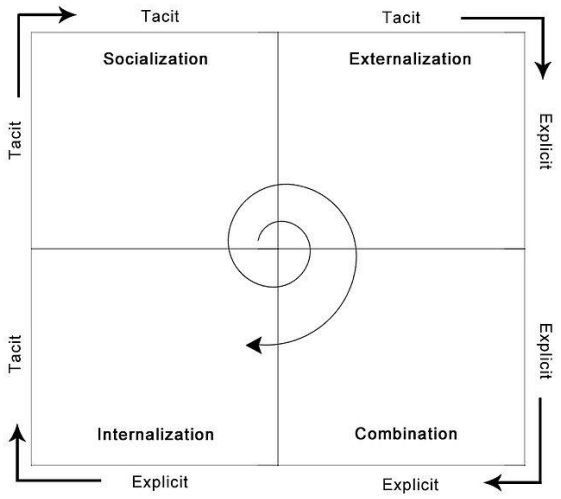
2.3 Benefits of Tacit Knowledge

An organization is being bestowed with the following benefits from Tacit Knowledge:

- Competitive Advantage
- Increased ROI
- Increased Employee Productivity
- Increased Effectiveness
- Improved Collaboration
- Faster Innovation Rate

2.4 Tacit Knowledge to Explicit Knowledge Conversion [5]

- Socialization
- Externalization
- Combination
- Internalization



3. Knowledge Assets

Knowledge Assets consist of guidelines, set within business context, enlivened by stories and quotes from experience, and linked to people and documents for further investigation. The role of knowledge assets in knowledge management is to provide the means by which one team or person can transfer their knowledge to many teams or people, separated in time and distance. A Knowledge Asset is an explicit managed resource which supports organizational decision-making and action. It contains synthesized, validated and organized knowledge. [6]

4. Knowledge Artifacts

It is a common practice that people, spontaneously and often implicitly; identify structures that make their cooperation and problem solving activities more effective. When these structures are sufficiently worked out and put at work, they are usually materialized in artifacts in various dimensions such as conceptual, linguistic and/or modeling tools, whose structure is strictly shared by the members of a well-defined community. Knowledge artifacts incorporate the core competences as well as the experiences of actors who are professionals skilled in possibly different disciplines, each of them characterized by a specific professional language. [7]

A knowledge artifact is any object that conveys or holds *usable* representations of knowledge. As any object, Knowledge Artifacts can be transferred, shared, and preserved. Moreover, *usability* of a Knowledge Artifact is interpreted as its ability to be put into action by a human actor in an organizational context. They are *primarily* used to *objectify* how people within an organization and community organize their "memories" and the involved "knowledge" and how people are able to put it into use to make proper and timely decisions.[8]

5. Knowledge MAP

A Knowledge map is a navigational aid that enables a user to hone in rapidly on the desired concept, and then follow links to relevant knowledge sources (information or people).[9]. It can provide an overview of the relationships between different areas and types of knowledge. The organizational knowledge map is an outcome of synthesis within the organization and portrays the sources, flows, constraints, and sinks of knowledge within an organization. An organizational knowledge map highlights the following:

a. Location, ownership, validity, timeliness, domain, sensitivity, access rights, storage medium, use statistics, medium and channels of common organizational data, information and knowledge pools or sources.
b. Organizational documents, files, systems, policies, directories, competencies, relationships, authorities
c. Boundary objects, knowledge artifacts, stories, heuristics, patterns, events, practices, activities
d. Explicit

6. Organizational Memory

Memory is an essential component of learning, because it accommodates learning. One interesting aspect of health human memory is that it never seems to run out of space. [10] Stein and Zwass (1995) define Organizational Memory as the means whereby knowledge from the past is brought to bear on present activities resulting in higher or lower levels of organizational effectiveness. It integrates information across the organizational boundaries and to control current activities and thus avoid past mistakes. Generic

functions of Organizational Memory are perception, acquisition, abstraction, recording, storage, retrieval, interpretation, and transmission of organizational knowledge.[11]

7. Adaptive Resonance Theory (ART) Neural Networks

Adaptive resonance theory (ART) networks (Carpenter and Grossberg 1988) are most useful for pattern clustering, classification (e.g., signal classification), and recognition. They can also perform pattern association with some modifications. These networks can work on binary or analog-valued input. The adaptive resonance theory suggests a solution to the stability-plasticity dilemma during the designing of learning systems. The dilemma asks: "How can a learning system be designed to remain adaptive in response to significant events and yet remain stable in response to irrelevant events?" It would be easy either to learn new patterns (learning plasticity) or retain the knowledge of previously learned patterns (learning stability). One of the key features in attaining learning plasticity and stability is the use of pattern resonance.

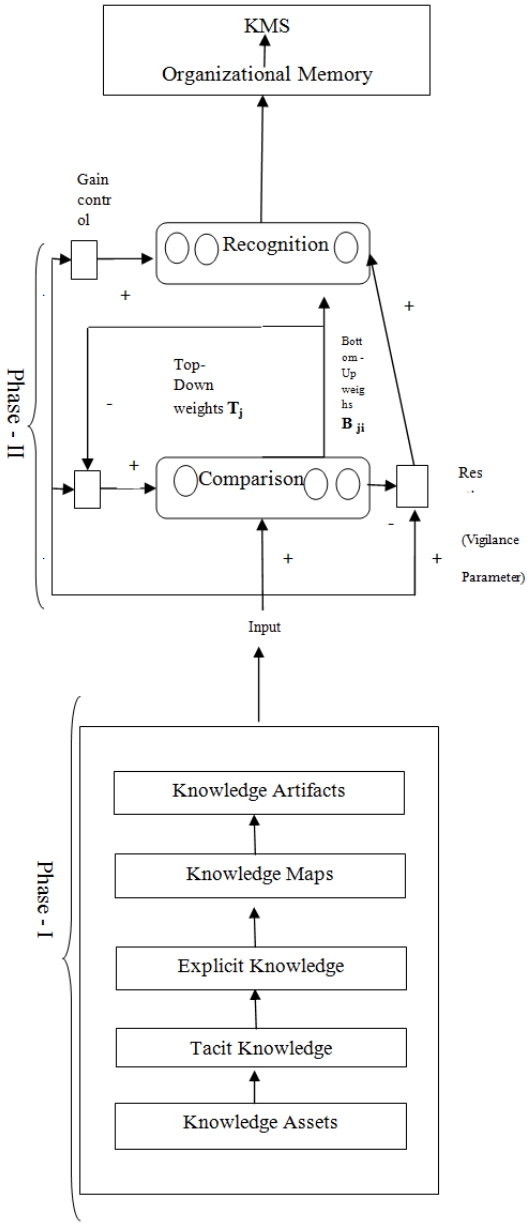
An ART Network uses resonance of a pattern in the output layer, with a pattern in the input layer, to establish a good hetero-associative pattern match. A resonating network has two main layers. The first layer receives and holds the input pattern. The second layer responds with a pattern classification or association to the input pattern (*the recognition layer*) and verifies that by sending a return pattern to the first layer (*the comparison layer*). If this return pattern is correct (similar to the input pattern), then there is a match. If the return pattern is substantially different from the input pattern, then the two layers will resonate by communicating back and forth, seeking a match. If a novel input pattern fails to match stored patterns within the tolerance level (imposed by the so-called vigilance parameter), a new stored pattern will be formed.

III. RESULTS AND DISCUSSION

8. Deployment

The proposed solution in KM Systems development is achieved through the deployment of ART Neural Networks algorithm. The following are the limitations that confine the superior performance of typical Knowledge Management System:

i. Knowledge engineers might not be able to extract the complete expertise from the Domain (human) experts which limits the scope of the knowledge base.
ii. Autonomous functioning of the system is being constrained even after satisfactory iterations, as it also needs to be tweaked through human-interventions, and through case-based reasoning, Incremental learning, and continuous adaption to the environment is not practically possible
iii. Does not learn from mistakes unless user feedback and human maintenance is part of its ongoing development



All the foregoing limitations / drawbacks are being overcome by virtue of deploying ART Neural Networks which falls under unsupervised learning neural networks. It is far more superior to many other types of neural networks, addressing the Stability-plasticity dilemma excellently.

The crux of the proposed solution centers on the very fact that KM System through a robust organizational memory is pursued in such a manner that it is highly productive, and fault-tolerant. Productive in a sense that it encodes the experience (tacit knowledge) of the seasoned employees, and finally makes it available organizational-wide usage perpetually. As such, organizations stand to get benefitted as the intangible competitive asset – the knowledge – is being captured, codified and made available even after the seasoned / veterans of an organization leave the organization on natural grounds or for much better opportunities elsewhere (knowledge walk-outs).

PHASE – I

The Phase I concentrates on in-taking all the knowledge assets of an organization in order that tacit knowledge ingrained in the minds of the employees is being made to be explicit knowledge. Nonaka's spiral process is being employed to convert the tacit knowledge into explicit knowledge.[5]. Once, the ingrained experience in any operational or strategic transaction or during the course of executing any project; is being converted into digitized explicit knowledge, knowledge maps are being constructed so as to result in knowledge artifact. But each knowledge artifact need not play an indispensable role. Thus, the validity of each knowledge artifact towards to the merit of storing it in the organizational memory is being authenticated by the deployment of ART-2 Neural Networks in the Phase II.

PHASE – II

ART Neural Network has a two-layered architecture as depicted in the above-given diagram. The input into the ART is the knowledge artifact which refer to a unwritten decision resulting in the organizational benefit as taken by an executive of the organization, way in which an exceptional / uncertain situation was being managed, critical decision taken, factors that favored the accomplishments of the determined corporate-goals or otherwise, resolutions to be pursued to arrest a particular business-case, and the like. Such a knowledge artifact will be received from the Phase I and will be fed in the ART Neural Network.

ART Algorithm

- Weight Initialization

The ART net consists of two layers: the input and the output layers. The connection weight $B_{i\,j}$ (t) (called a bottom-up weight) points from unit i in the input layer to unit j in the output layer at time t. The connection weight $T_{i\,j}$ (t) (called a top-down weight) points from unit j in the output layer to unit i in the input layer at time t. These weights define the stored pattern associated with output unit j:

$$T_{i\,j}(0) = 1$$

$$B_{i\,j}(0) < L / (L - 1+m)$$

where m is the number of input units, and L > 1 (L is a constant; typically L=2).

- Calculation of Activation
  - The activation levels of the input units are determined by the input pattern.
  - The activation level of an output unit is calculated by the following procedure:

1. $$I_j = \sum B_{j\,i}\, X_i$$

and

$$O_j = F_w(I_j)$$

where O_j is the activation level of output unit j, X_i is the activation level of input unit i, and F_w is a winner-take-all function such that

$$F_w(I_j) = \begin{cases} 1 & I_j = \max_i \{I_j\} \\ 0 & \text{Else} \end{cases}$$

2. Vigilance test: Suppose output unit j is the winner neuron. If

$$(\sum_i T_{i\,j} X_i) / (\sum_i X_i) > \sigma$$

where X_i is the activation level of input unit i, and σ is a vigilance parameter,

$0 \le \sigma \le 1$, then update weights; else set $O_j = 0$, disable the output unit j,

go to step 1, and repeat. If all committed output units (specifying stored patterns)

are disabled, then a new output unit is allocated and its weights are initialized as stated.

- Weight Training

$$T_{ij}(t+1) = T_{ij}(t)\, X_i$$

$$B_{ji}(t+1) = \frac{L\, T_{ij}(t)\, X_i}{L - 1 + \sum_k T_{kj}(t)\, X_k}$$

By applying the above-furnished ART Algorithm with winner take-all strategy, a relevant knowledge artifact is learnt by the neural network by being stable to irrelevant knowledge artifacts which the organization might not leverage with. Such irrelevant knowledge artifact need not necessary be associated with an output vector which eventually reaches the organizational memory. In the recognition phase, the network finds the output neuron whose bottom-up weight vector (**B**) is closest to the input vector (**X**) in terms of their dot product.

B . X

This is essentially the winner-take-all strategy. In other words, after each knowledge artifact is being compared with their likely output vector, competing with each other knowledge artifact's match with the output vectors in the Recognition layer; the knowledge artifact having a close match will emerge as the winner. Only a winner, the knowledge artifact, when output by the ART Neural Networks, enters the organizational memory reservoir. This process exactly mimics the tasks of a knowledge engineer trying to extract the tacit knowledge from a domain expert. As the number and method is kept sophisticated for interviewing the domain expert, the knowledge engineer stands to extract effective tacit knowledge. Similarly the more knowledge artifacts which are relevant for gaining competitive advantage to an organization, the ART Neural Network gains plasticity; and the more irrelevant, and knowledge artifact manifesting generic form of knowledge without competitive benefits, the ART Neural Network remains stable. In this way the Stability-Plasticity problem in KM System development is being dealt with flawlessly.

PHASE – III

The Organizational Memory, here in the Phase III, would embody information about a specific instance of a strategic / operational transaction along the line of where an organization is competing with the corporate-rivals. Say for example, organizational memory may have a pertinent knowledge artifact concerning selecting an OEM manufacturer in Taiwan for kick-starting the sale of cost-effective Android-powered smart phones. This would also represent knowledge about the gamut of smart phone industry. In the discussed example, to freeze from whom to source the OEM for making a maiden-entry into the Android-powered smart phone merchandizing after a great deal of product-positioning. If a unique knowledge artifact fails to match stored patterns within the tolerance level (imposed by the so-called vigilance parameter), a new stored pattern will be formed. Tolerance level can have its enclaves based on the organization's corporate statistics such as the type market the organization has been into, (monopoly, oligopoly, perfect competition, etc) demographics, price-points, competitor's strategies, customer-base / customer loyalty, and the like.

IV. LIMITATIONS

The limitations of this proposed solution could straight-forwardly be anticipated, and avoided as they rest on 'theory of constraints'. Theory of Constraints amplifies that a chain is no stronger than its weakest link, the proposed solution's charm could be lost if there are 'weakest' / unproductive, irrelevant and unfitting knowledge assets being identified which starts the upward movement and finally is highly responsible for generation of knowledge artifacts as per Phase I and the magnitude of the 'weakest link' protrudes until the Phase II in the architecture of the proposed solution. With erroneous knowledge artifacts, and the faked organizational memory bank with such knowledge artifacts, the KM Systems developed will only culminate to a point of absolute failure. The role of the Knowledge Engineer / developer cannot still be eliminated in finalizing the Knowledge Artifacts as he / she will be the first point of contact with the Expert whose expertise and its subsequent distribution across the organization is the pivotal point of Knowledge Management.

V. CONCLUSION

The scope of the proposed solutions spans to versatile industries and numerals verticals within each industry. The viability of the proposed solution is such that the monetization strategies are within attainable ceilings.

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