Chinese Character Recognition Algorithms for Intelligent Transport Systems

David Al-Dabass
School of Computing & Technology
Nottingham Trent University
Nottingham, NG1 4BU, UK
david.al-dabass@ntu.ac.uk

Manling Ren
Xerox Limited Technical Centre
Welwyn Garden City
Hertfordshire AL7 1HE, UK

- Automatic recognition of Chinese character signs in real time could ultimately form an important part of street navigation in an intelligent transport system.

- In this paper the structure of Chinese characters is reviewed and seen to consist of a 3-layer hierarchy of character, radical and stroke.

- Fuzzy possibilistic reasoning is put forward as an appropriate set of algorithmic tools to aid automatic recognition of these characters.

- Associative memory artificial neural network algorithms form a suitable technique for realising these concepts.

- Implementing these techniques several issues are explored: vagueness of radicals, their situation, position invariance, extraction order and shape.

- Extensive results are obtained to demonstrate the quality of the algorithms in dealing with the range of difficulties inherent in the problem.

1. Introduction

2. Elements of Language Theory

3. Algorithms

4. Implementation

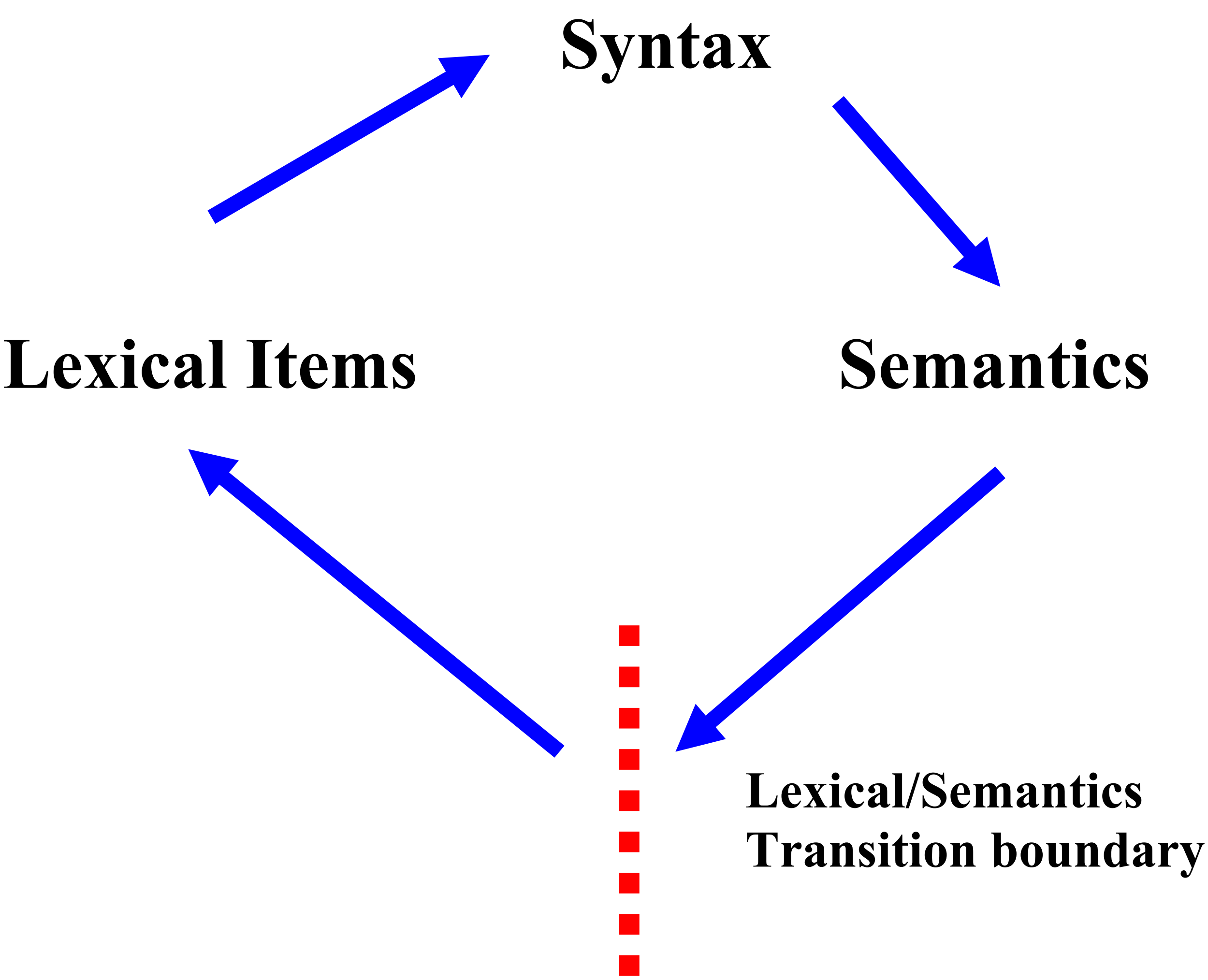
5. Results

6. Conclusions

2. Elements of Language Theory

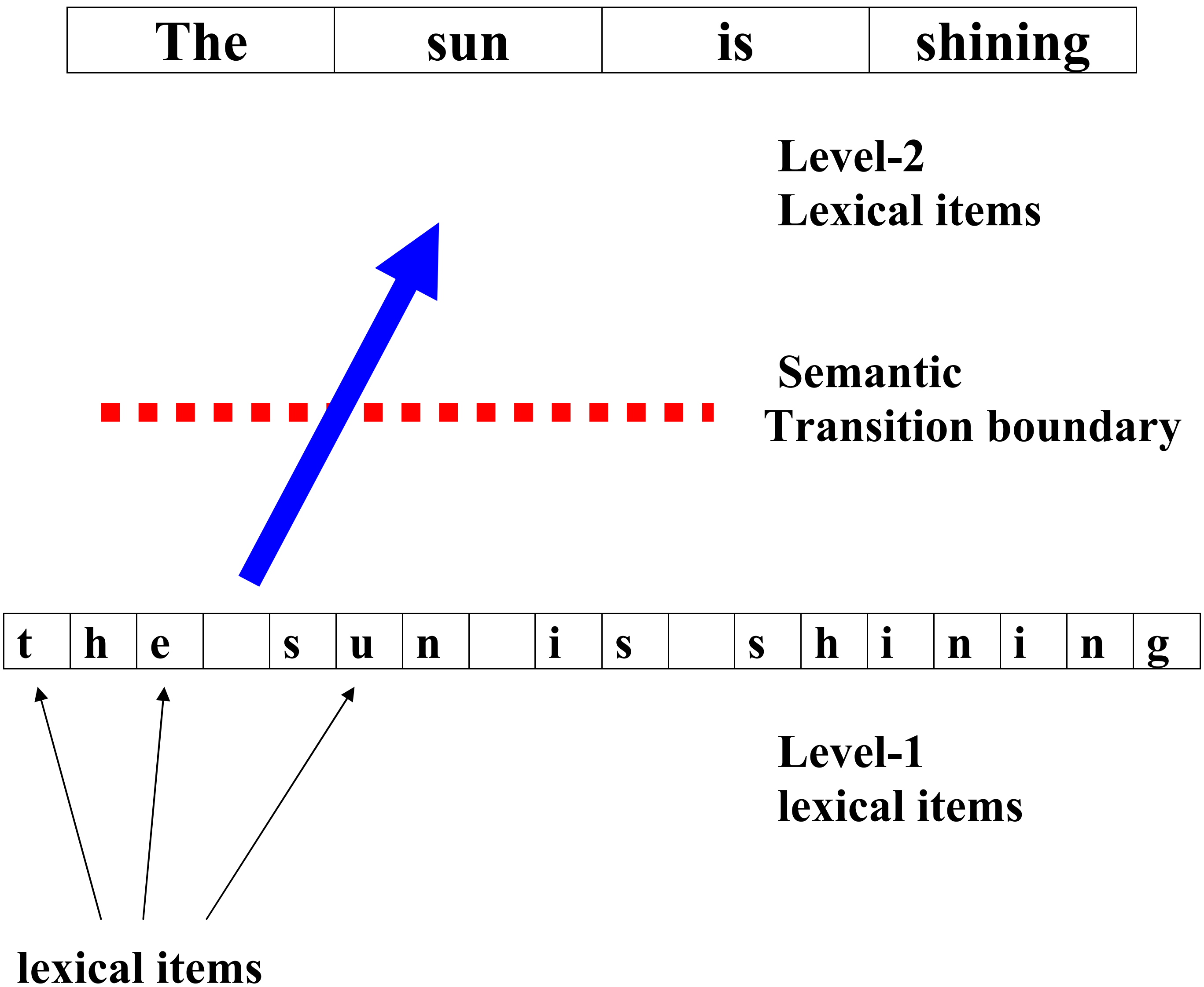
Review of the Relationship between Semantics, Syntax and lexicons.

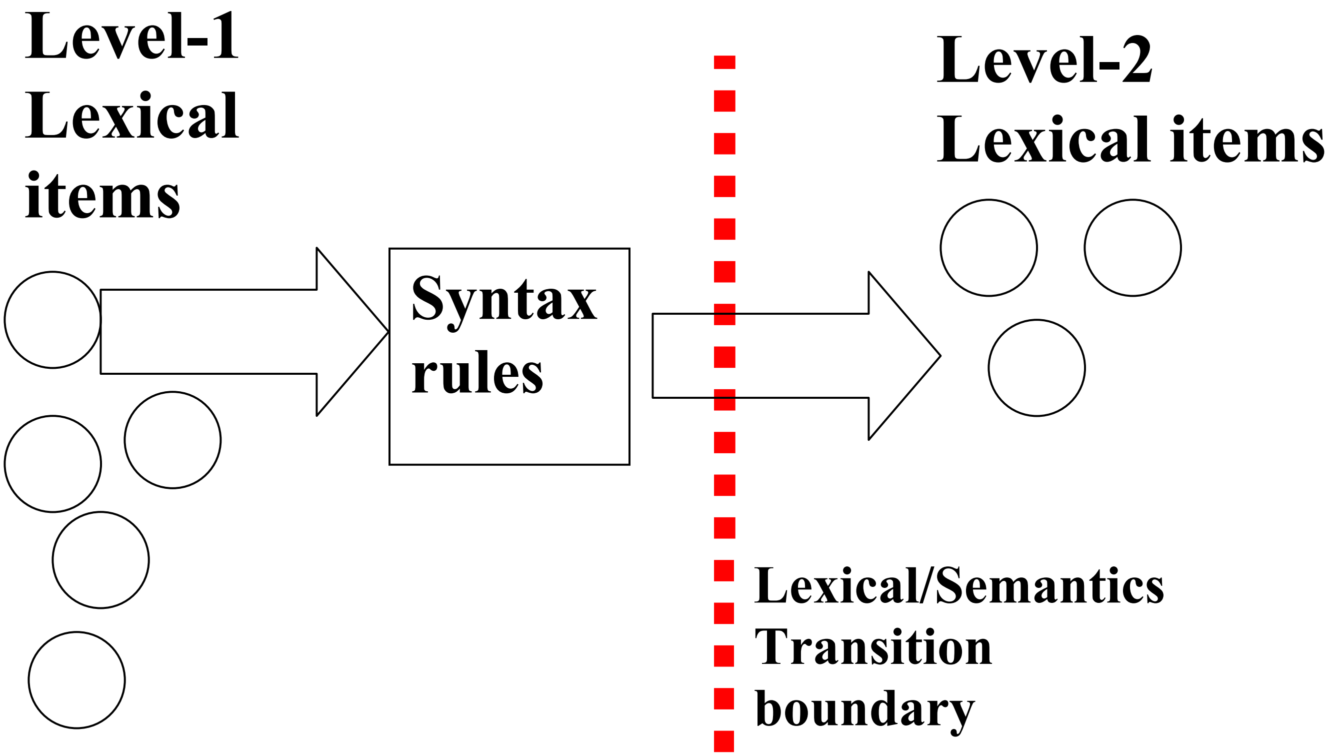
- **Lexical items put together in a special way (Syntax) to form a meaningful higher entity**
- **These new higher entities are the lexical items for a new language level**



Example:

The sun is shining





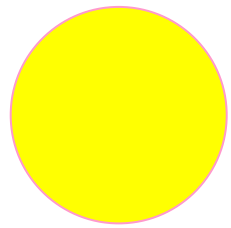
Syntax rules

- one dimensional, e.g. sequential language: the sun is shining

The syntax is 'distant' from the semantics, i.e. syntax-semantics relationship is weak.

Two-dimensional/pictorial languages

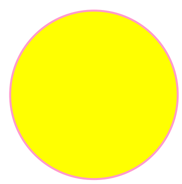
sun is shining

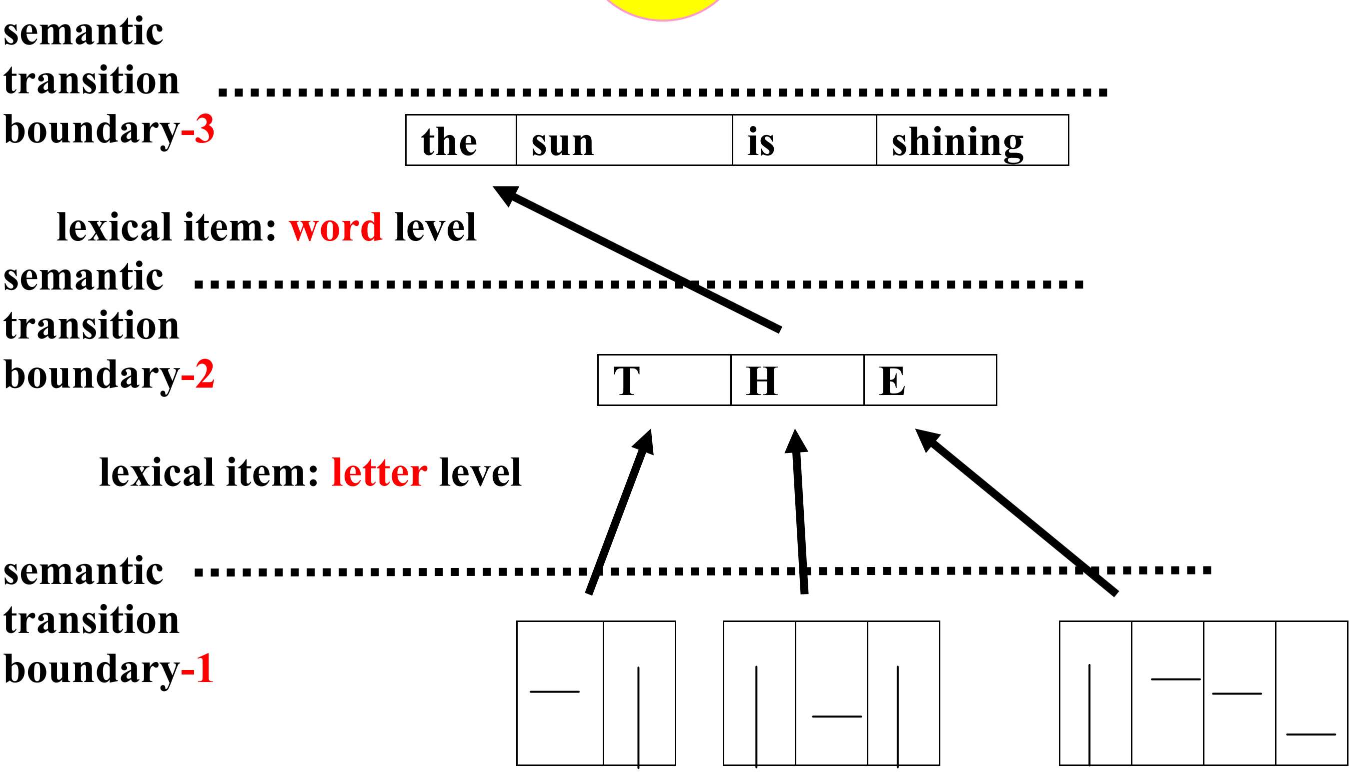


syntax-semantic relationship is strong

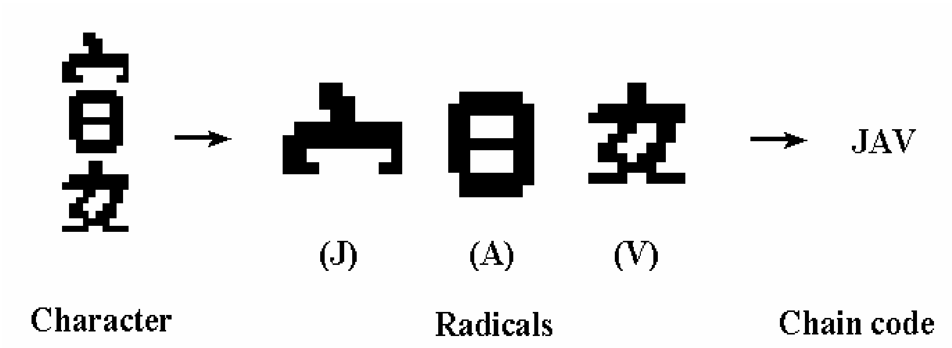
- **each word in a 1-D language is a 2-d lanaguge item**
- **each letter is also a 2-D item**

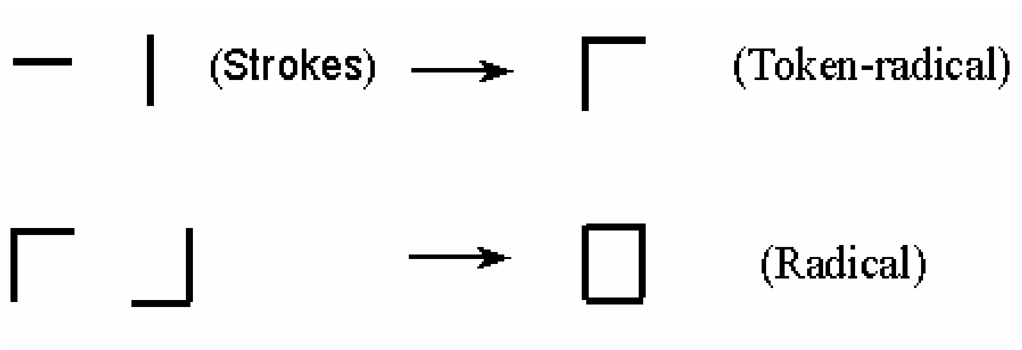
sentence/concept level

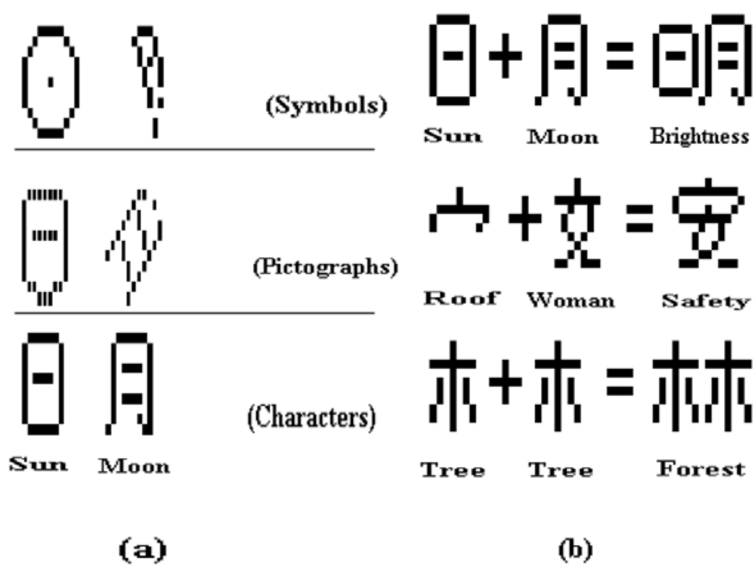




lexical item: stroke level







The historical development of Chinese characters

3. Algorithm

Expression: Generally, a possibilistic inference rule $\Re_j$ can be expressed by

$\Re_j$: **IF** ξ^S_j **is** μ_j **THEN** ξ^T_j **is** v_j, $j = 1, ..., r$,
or
$\Re_j$: **IF** $\xi^S_j{}^{(1)}$ **is** $\mu_j{}^{(1)}$ **AND** $\xi^S_j{}^{(2)}$ **is** $\mu_j{}^{(2)}$ **THEN** ξ^T_j **is** v_j, $j = 1, ..., r$,

The algorithm contains two phases: learning and training.

In the learning phase, the associative memory function is used to form the connectivity matrix W for training a set of input patterns X_i (u) and output patterns Y_j (u),

$$W(i, j) = \begin{cases} \sum_u X_i(u) Y_j(u) & if \quad i \neq j \\ 0 & if \quad i = j \end{cases}$$

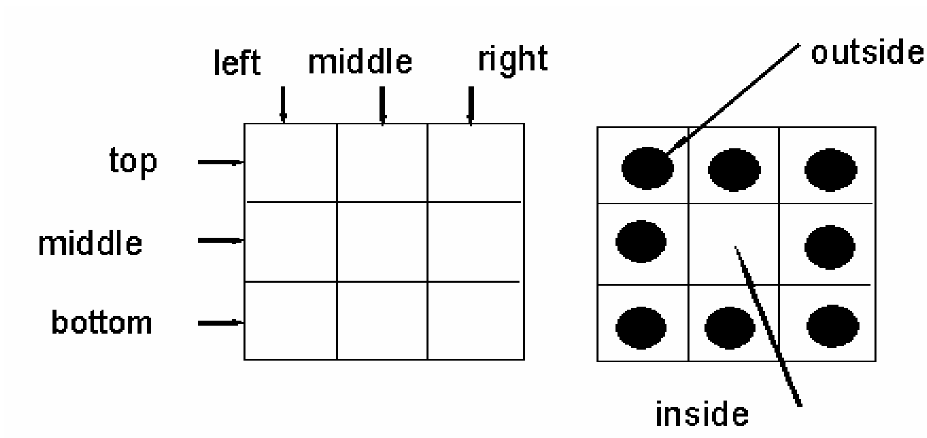
In the training phase, the algorithm aids convergence because its value in equation (3.1) is either reduced or to remain constant during the recall procedure [Wan94], providing the following conditions are satisfied.

$$E = -\sum_{i}\sum_{j} X_j W_{ij} Y_j + \sum_{i} \theta_i X_i + \sum_{j} \varphi_j Y_j \qquad \cdots \quad (3.1)$$

$Y_j^{n+1} = \begin{cases} 1 & \sum_i W_{ij} X_i^n - \varphi_j > 0 \\ Y_j^n & \sum_i W_{ij} X_i^n - \varphi_j = 0 \\ -1 & \sum_i W_{ij} X_i^n - \varphi_j < 0 \end{cases}$ $X_i^{n+1} = \begin{cases} 1 & \sum_j W_{ij} Y_j^n - \theta_i > 0 \\ X_i^n & \sum_j W_{ij} Y_j^n - \theta_i = 0 \\ -1 & \sum_j W_{ij} Y_j^n - \theta_i < 0 \end{cases} \quad \cdots \quad (3.3)$	**The relation $\Re$ of all rules is** $\Re = \bigcap_{j=1}^{r} \Re_j$

4. Implementation

Vagueness of radicals



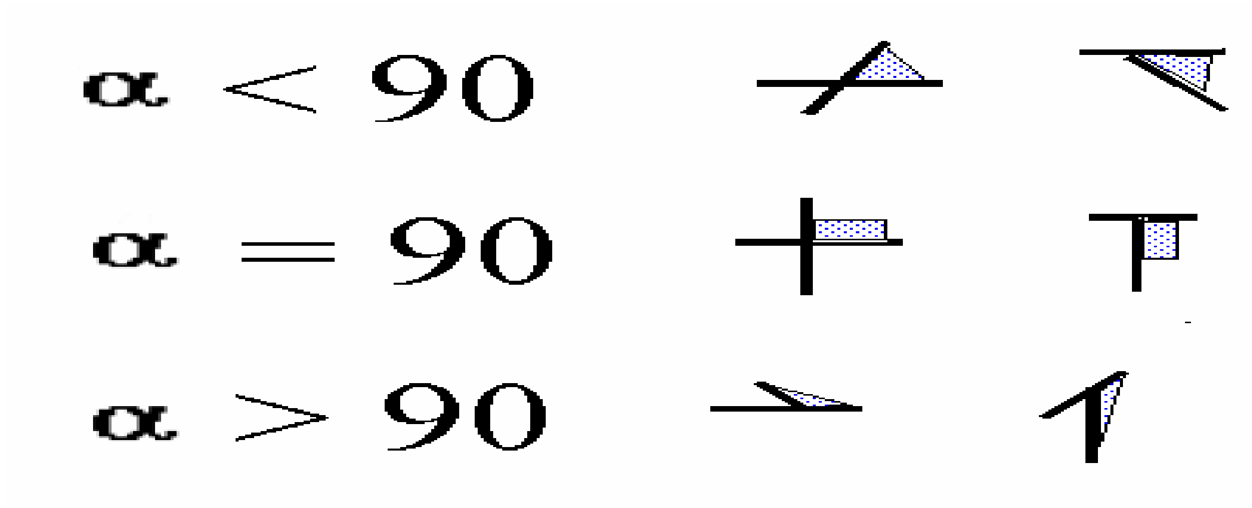
Position Variance: The domain of position variable is defined by

P = {***width, length***}.

Because a radical may keep an independent position in a character, the possibility distribution of position variance of a radical on the domain P, shown above is defined by

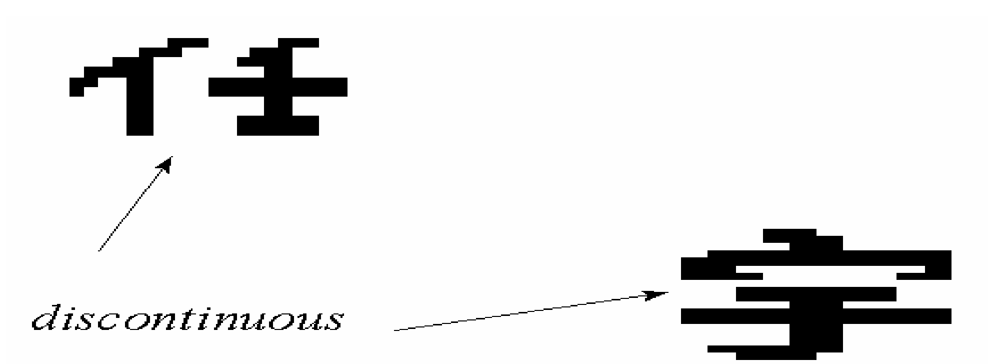
π(P) = {***outside, inside, top, bottom, left, right, middle***}
$Poss_\pi$ (P) for π(P) is defined by, for instance,
$Poss_\pi$ (*left*) = {***width ≤ 2/3 width of P, length = length of P***}.

Shape Vagueness



Angle of strokes connected

Location of strokes connected



Discontinuous contour

Architecture of the Associative Memory Neural Network

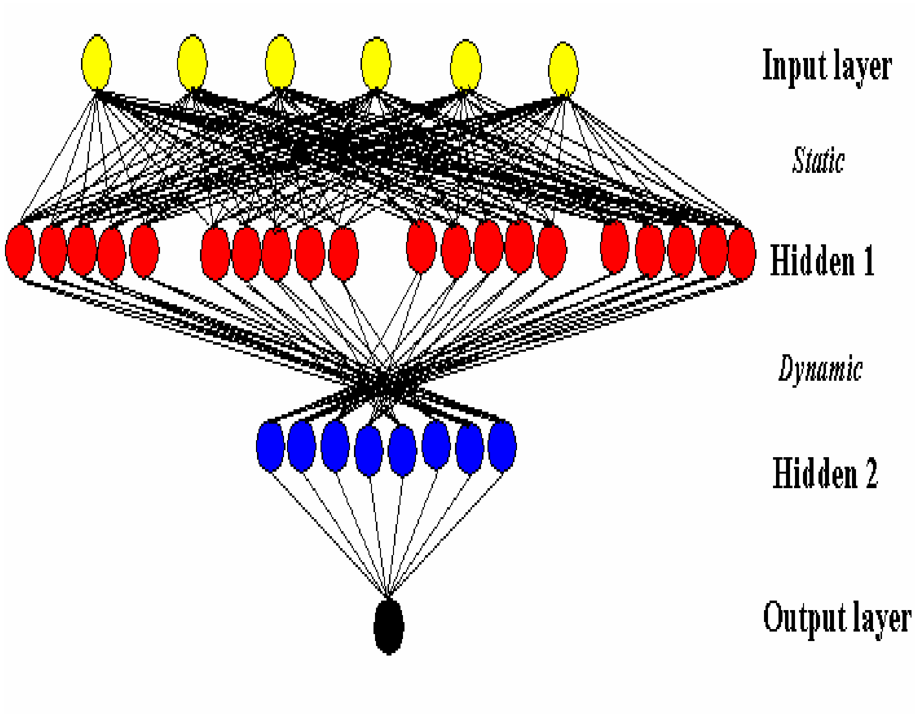


Figure12: Architecture of the associative memory neural network

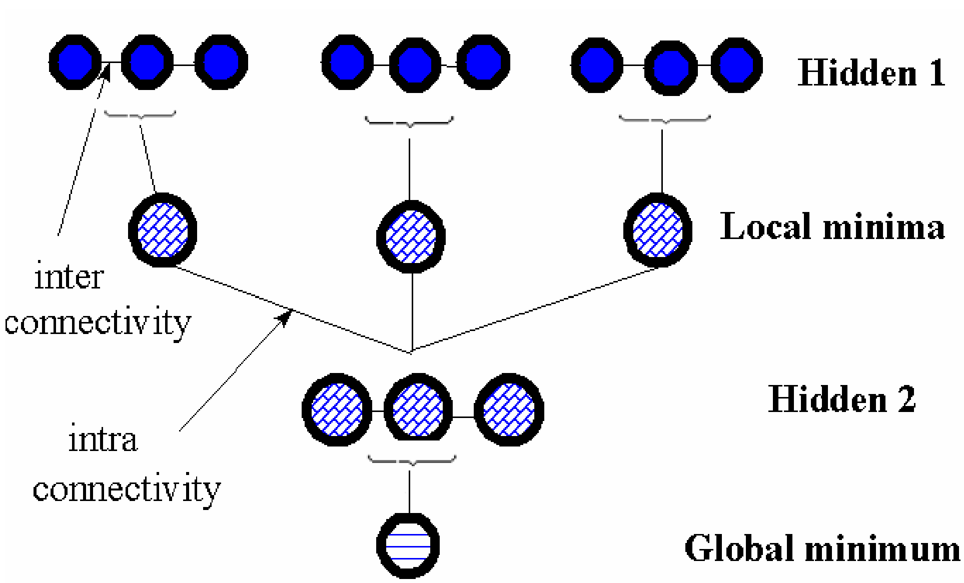
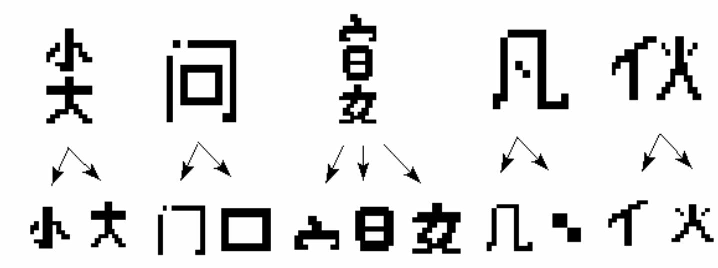


Figure 13: Function of the hidden-2 layer

5. Results

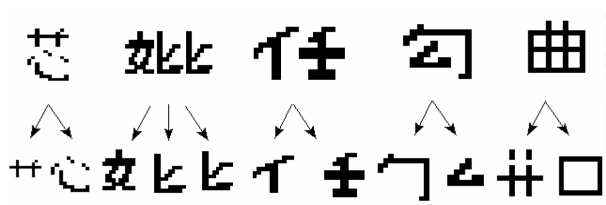
Extraction of Radicals

Test characters

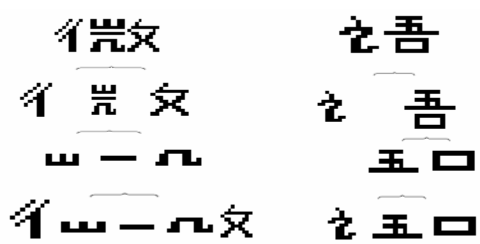


Different shapes of radicals

Different Positions:



Results of different orders



Examples for expansibility of rules

Classification and Recognition of Radicals

Group: Philosophy

Category	Name	Standard Radical	Radicals/ Token-radicals
A	Sun	日	门(N) 日
B	Moon	月	冂 冖
C	Metal	金	儿 钅
D	Wood	木	
E	Water	水	氵 又
F	Fire	火	小 灬
G	Soil	土	士

(a)

Group: Stroke Combination

Category	Name	Standard Radical	Radicals/ Token-radicals
H	Left-diagonal	竹	几(H) 壬(B) 彳(D) 斤(L) 壬(R)
I	Dot	戈	丶 厶 之(I) 丬(L)
J	Cross	十	宀
K	X connection	大	乂 力(S) 攵
L	Vertical	中	由(W) 阝
M	Horizontal	一	五(M) 石(I) 手(D) 歹(H) 工 邛(G)
N	Hook/Turning	弓	刂

(b)

Group: Physical Symbol

Category	Name	Standard Radical	Radicals/ Token-radicals
O	Person	人	亻
P	Heart	心	勹 七 毛 匕
Q	Hand	手	扌 丰 丰(J)
R	Mouth	口	
X	Difficult		
Z	New		

(c)

Group: Shape Similarity

Category	Name	Standard Radical	Radicals/ Token-radicals
S	Flanking open	尸	丁 匚
T	Abreast balance	廿	艹
U	U shape	山	凵
V	Twisting shape	女	纟(F)
W	Square	田	囗 四(L)
Y	Y shape	卜	文(K) 讠(R)

(d)

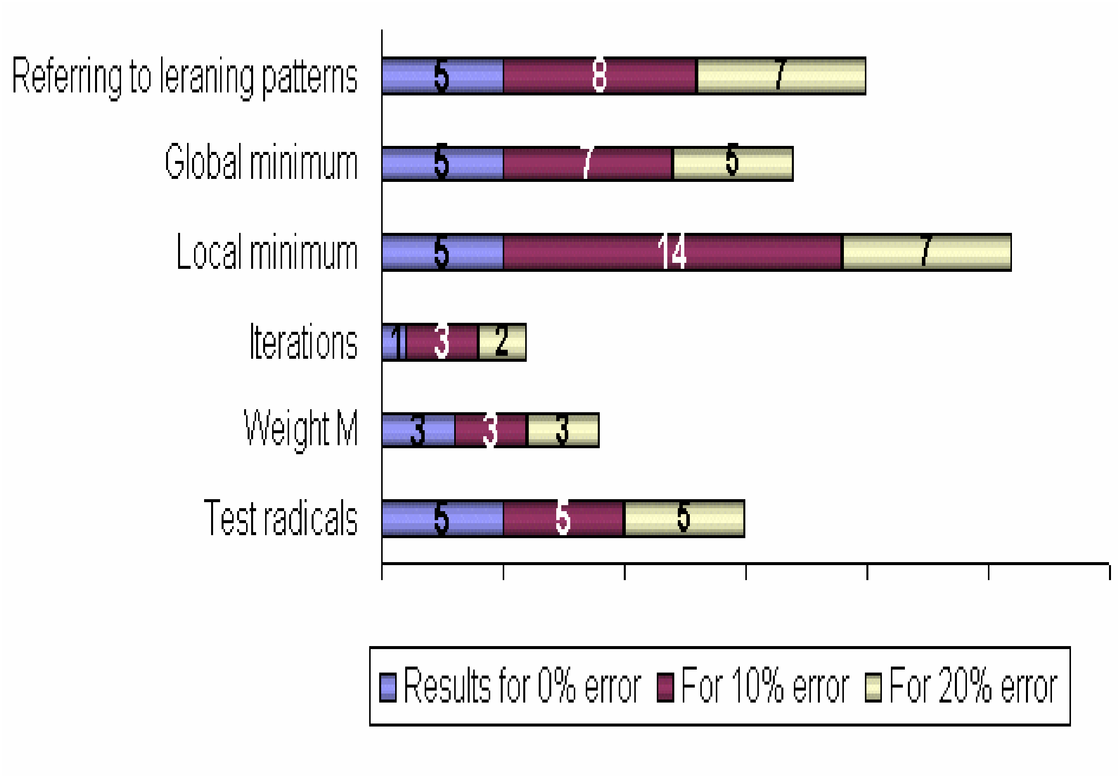
Classification of test radicals

Some learning patterns

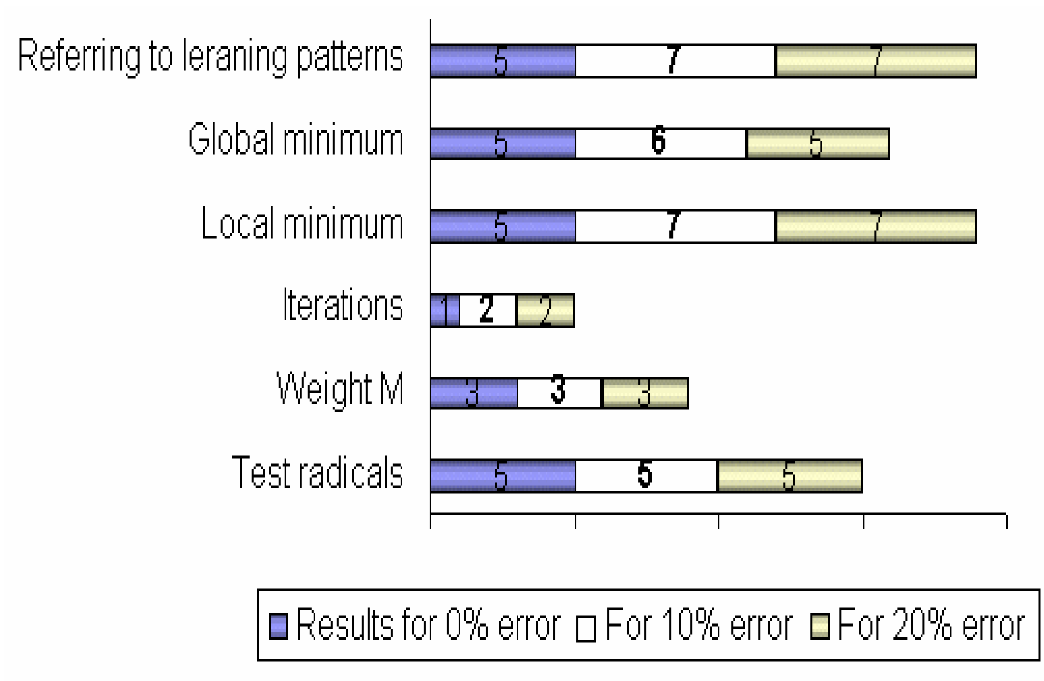
Classification

Learning Phase

The Modified Network



Test results with setting the parameters θ_i and φ_j to 0



Test results with modifying the parameters θ_i and φ_j to ½ $\sum W_{ij}$

6. Conclusions

- Automatic navigation around city streets depends on several elements, one of which would rely on the use of computer recognition of illuminated text such as Chinese language signs.

- The work described in this paper represents a significant advance towards using the method of three-layer hierarchy character-radical-stroke for the representation of the structure of Chinese characters, and the process of character-radical-chain code to identify it.

- Although work in the pre-processing stage has classified positions of radicals in a character, a case that allows omitted and difficult radicals in a character has not been considered yet.

- Basically, a character in such a case has a very complex structure and it is written in a complex style. Applying fuzzy possibilistic rules to such characters and more complex characters can be investigated in future development.