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A Generalized Net Model of the Process of Scene Analysis

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In memory of our colleague and friend
Professor Dr Vassil Vassilev

Abstract: *A generalized Net model describing the process of computer scene analysis is developed. It takes into account both the objects in the scene background. The flexibility of the model allows its implementation in different specific applications.*

Keywords: *Generalized Net, scene analysis, image enhancement, segmentation.*

1. Introduction

Recently a few Generalized Net (GN) models [1, 2] have been suggested for dealing with different aspects of image processing and pattern recognition, such as in face recognition, writer recognition, speaker recognition, and the like [3, 4]. In this paper we shall describe the first GN-model for the process of analyzing scenes (see, e.g. [5]). Since the problem of scene analysis is quite complicated and its proper complete solution depends very much on the specificity of the particular applications, we, following and extending [6], shall just outline here a general model. A fully-fledged model will require the development of sub-nets to reflect the peculiarities of each particular task.

2. A generalized net model

Here we shall construct a GN to describe the process of scene analysis (see Fig. 1).

The GN contains 8 transitions, 18 places and four α, β, γ and δ types of tokens. All the numberings from [6] have been retained.

Initially, token β is placed in place l_{12} with initial characteristic

"Data Base (DB) of objects and their parameters",

while tokens denoted by α enter sequentially place l_1 with initial characteristic

"scene digital image".

For brevity the notation α will be used for all other tokens where possible including the the current one.

Initially, token δ is placed in place l_{18} with initial characteristic

"criteria for data base extending with the current scene".

Transition Z_1 is described as

$$Z_1 = <\{l_1\},\{l_2, l_3, l_4\}, \begin{array}{c|ccc} & l_2 & l_3 & l_4 \\ \hline l_1 & W_{1,2} & W_{1,3} & W_{1,4} \end{array} >,$$

where

$W_{1,2}$ = *"noise reduction is necessary"*,

$W_{1,3}$ = *"contrast enhancement is necessary"*,

$W_{1,4}$ = *"background elimination is necessary".*

Entering transition Z_1, token α could split into three tokens if the original image needs to be processed by different procedures. Each of the new tokens will be interpreted as an α-token. They obtain the following characteristics:

"digital matrix of the smoothed image"

in place l_1,

"digital matrix of the sharpened image"

in place l_3,

"digital matrix of the extracted objects in the image"

in place l_4.

All of them will transfer independently in the next transition and all of them will unite in place l_5 generating again only one α-token. Let us denote the current characteristic of each of α-tokens by x_{cu}^{α}.

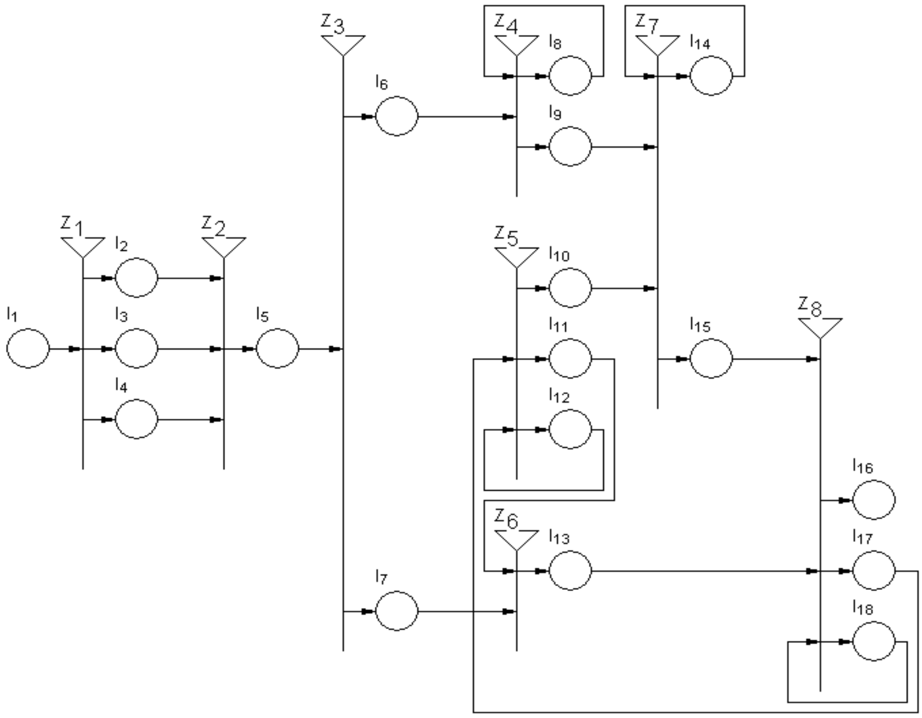

Fig. 1

Transition Z_2 has the form

$$Z_2 = <\{l_2, l_3, l_4\},\{l_5\}, \begin{array}{c|c} & l_5 \\ \hline l_2 & true \\ l_3 & true \\ l_4 & true \end{array} >.$$

The token has the characteristic

"enhanced image"

in place l_5. At the transition

$$Z_3 = <\{l_5\},\{l_6, l_7\}, \begin{array}{c|cc} & l_6 & l_7 \\ \hline l_5 & true & true \end{array} >,$$

the current α-token splits into two tokens. Let us denote them by α and γ. The α-token obtains the characteristic

"object separation from the background"

in place l_6, while the γ-token obtains the characteristic

"image background"

in place l_7.

$$Z_4 = <\{l_6, l_8\},\{l_8, l_9\}, \begin{array}{c|c|c} & l_8 & l_9 \\ \hline l_6 & W_{6,8} & true \\ l_8 & W_{8,8} & true \end{array} >,$$

where

$W_{6,8}$ = *"there is more than one object in the original scene",*

$W_{8,8}$ = *"there are at least two object in the list of objects".*

The α-tokens gain the characteristics

"remaining objects in the scene"

in place l_8,

"parameters of the currently found object"

in place l_9.

$Z_5 = <\{l_{12}, l_{17}\},\{l_{10}, l_{11}, l_{12}\},$

	l_{10}	l_{11}	l_{12}
l_{12}	$W_{12,10}$	$W_{12,11}$	*true*
l_{17}	*false*	*false*	*true*

$>$,

where

$W_{12,10}$ = *"some token enters place* l_9*",*

$W_{12,11}$ = *"some token enters place* l_7*".*

Token β, which stays permanently in place l_{12}, can split into two or three tokens – β, β' and/or β''. Token β' enters place l_{10} with a characteristic

"information from DB *related to the object represented by the current α-token in place* l_9*"*

Token β'' enters place l_{11} with a characteristic

"information from DB *related to the background represented by"*

"the current α-token in place l_7*".*

If there is a δ-token in place l_{17}, it will enter place l_{12} and will unite with token β, which obtains as a current characteristic

"extension of the DB *with information for a new recognized scene".*

$Z_6 = <\{l_7, l_{11}\},\{l_{13}\},$

	l_{13}
l_7	*true*
l_{11}	*true*

$>$.

Tokens γ from place l_7 and β'' from place l_{11} unite in token γ which has the characteristic

"recognised background"

in place l_{13}.

$Z_7 = <\{l_9, l_{10}, l_{14}\},\{l_{14}, l_{15}\},$

	l_{14}	l_{15}
l_9	*true*	*false*
l_{10}	*true*	*false*
l_{14}	$W_{14,14}$	$W_{14,15}$

$>$,

where

$W_{14,14}$ = *"there are more tokens in places* l_8 *and* l_9 *",*

$W_{14,15} = \neg W_{14,14}$,

where $\neg P$ is the negation of predicate P.

Tokens α and β' unite in token α which has the characteristic

"identification of the current object"

in place l_{14}. When all the α-tokens which have been generated by the initial one are collected in place l_{14}, they go to place l_{15}, where they are united in one α-token that after this obtains the characteristic

"list of all objects from the scene".

$$Z_8 = <\{l_{13}, l_{15}, l_{18}\},\{l_{16}, l_{17}, l_{18}\}, \begin{array}{c|c|c|c} & l_{16} & l_{17} & l_{18} \\ \hline l_{13} & true & false & false \\ l_{15} & true & false & false \\ l_{18} & false & W_{18,17} & true \end{array} >,$$

where

$W_{18,17}$ = *"the criteria for the data base extension with the current scene are satisfied".*

The current tokens α and γ unite in one α-token that obtains the characteristic

"description of the natural disposition of the objects in the scene"

in place l_{16}. When $W_{18,17}$ = *true* token δ splists to two tokens – δ that continues to stay in place l_{18} and token δ' that enters place l_{17} with a characteristic

"initial and final characteristics of the current token".

The GN-model constructed in this way describes the process of scene-analysis and could be used for the description of many different kinds of such applications.

3. Conclusion

In this paper we have presented a GN-model of the process of scene analysis. The variety of practical problems that can be treated in such way does not permit a detailed description of the specific procedures that could be required in each situation; that is, for each practical case specific sub-nets have to be developed. In any case the model suggested here could also be used as a general scheme, which could be applied to a large number of practically interesting problems related to the analysis of scenes.

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