Survey on various Classes of Picture Languages

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Abstract
A formal language is defined as a set of strings of an alphabet which is a non-empty set. In terms of pictures, a set of pictures are called as picture language in the field of formal languages. The study of picture languages was originally prompted by the problems of image processing and pattern recognition. The matrix grammar and tiling systems have been designed to describe the picture languages. Many problems in picture languages have been formulated from one dimensional formal language theory. A method of undecidability results for regular picture languages is used to show the undecidability of the equivalence problem in regular languages Jurgen; Friedhelm (1993). The methods of mathematical linguistics have been considered for picture generation and picture description. Generally mathematical linguistics deals with strings and not with pictures. Picture language is not recognizable and also proved that this type language is both star free and piecewise testable Rosenfeld (1970).

Keywords: Picture languages, Chain codes, Recognizable picture language, Kolam grammar, Collage grammar.

INTRODUCTION
Most of the approaches of picture languages includes chain code pictures, recognizable picture languages, hexagonal picture languages, tiling system, 2D picture grammar, kolam grammar and collage grammar. In this paper we concerned with various results of different classes of picture languages. The chain code is a method which is one of the popular picture processing approach. This chain code approach provides a connection between the pictures and the strings describing pictures. They associate a picture with a set of pictures and it is called as chain code picture language where picture is constructed by the symbols which is represented the sequence of drawing commands. Tiling system has the unique categorization which as locally testable languages and keeping up the properties of regular languages Alessandra et al. (2006). Extended 2D context-free picture grammar is a new theoretical model of grammatical picture generation E2DCFPG. Atwo dimensional grammar model is called as pure2D context-free picture grammar (P2DCFPG). A process of interpreting letter symbols with a picture array using primitive patterns is called as a technique for interesting classes of “kolam” Siromoney et al. (1972) pictures or chain code pictures Maurer et al. (1983). By applying these techniques, we can generate the 2DCFPG(Two dimensional context free picture grammar). Prusa introduced his new model to attempt to gain more generative capacity with respect to the class of Kolam grammars. This class of Kolam grammars has been derived from Array grammar, thereafter it is renamed as Kolam Array grammars which was introduced by Siromoney et al. (1973). A (context free)collage grammar is a system useful for generating pattern devices and it is completely based on hyper edge replacement. A collage comprises a set of parts and a sequence of pin-points. Mostly a part can be an arbitrary set of points in an Euclidean space. So the parts are taken from a set of geometric objects (circles, triangles, polygons, polyhedra) etc. Also they have very simple finite descriptions, so it is easy to deal with on the graphical surfaces. In the future investigations parts may also include colours, textures also. The pin-points are added to paste collages into collages.
Generally a picture is used for understanding the things better when compared with other modes. So, there is a lot technologies to compute pictures using computers. In the result of this computation of pictures, picture generating devices were introduced. The devices are based on weighted finite automata, two dimensional automata, the concept of generalization local languages from words and finally on different types of grammars that has been discussed by Jurgen Dassow (2006). Maurer et al. (1983) have proposed a picture description method, which is a word over the four alphabets containing left(r), right(r), up(u), down(d). It contains an attached basic picture and an attached drawn picture. Usually an attached basic picture formalizes the pictures, so that information is not given about how the picture is drawn.
1. An attached basic picture p and its equivalence class (∼) is denoted as [p], called as unattached version of p.
2. An attached basic picture q and its equivalence class (∼) is denoted as [q], called as unattached version of q.

A basic pictures are called as basic picture language and set of drawn pictures are called as basic drawn pictures base(D) = {base(q) | q ∈ D}, where D is a drawn picture language, base(D) is a base of D. Sigrid Ewert et al. (2009) has proposed a method of picture generation, it is called as random context
picture grammars(rcpg). The application of rcpgs is regulated, also its productions are context free.

Three important subclasses of rcpgs are,
1. Random permitting context picture grammars (rPcpgs).
2. Random forbidding context picture grammars (rFcpgs).
3. Table driven context free picture grammars(Tcfgs).

**Chain code-Picture Languages:**

Line drawing pictures can be described by the strings, called chain codes. Symbols used in chain code pictures are denoted as graphics command with certain direction along with its colour Changwook Kim (1996). There are many approaches to work out the problems in picture processing. An important approach is to solve a problem is chain code which derives a string and picture. Jurgen; Friedhelm (1993) have used eight directions and others pictures and it is a combination of string and picture. An important approach is to solve a problem is chain code which derives a string and picture. Important properties of chain code picture language has been studied and it includes formal-language theoretical properties which have been discussed in Kim (2002). The two fold Cartesian product of Z with itself is exemplified to as a universal point set. Z indicates as the set of integers. Consider, \( v = (m, n) \in \mathbb{Z} \), \( y(v) = n \).

- The up-neighbour of \( v \) is \( u(v) = (m, n+1) \)
- The down-neighbour of \( v \) is \( d(v) = (m, n-1) \)
- The left-neighbour of \( v \) is \( l(v) = (m-1, n) \)
- The right-neighbour of \( v \) is \( r(v) = (m+1, n) \)

The neighbourhood of \( v \) is defined as, \( N(v) = u(v), d(v), l(v), r(v) \)

In Jurgen Dassow (2006), directions of the pictures have been discussed. Connection of two neighbouring points which makes a straight line, called a unit line. So for any unit line, at any point \( z \in \mathbb{Z} \times \mathbb{Z} \). A direction be \( b \), \( f \), \( g \), and unit line connects \( z \) with \( b(z) \). So every picture has a finite unit line. An Example for unit lines in the below figure 1. They obtained the point set as follows, \( (1, 2); (1, 1); (0, 1); (-1, 1); (-2, 1); (-2, 0); (-2, -1); (-1, -1); (0, -1); (0, 0) \) So therefore the sequence is generated from this example is as follows, \( (z_0, z_1); (z_1, z_2); (z_2, z_3), \ldots, (z_{r-2}, z_{r-1}); (z_{r-1}, z_r) \)

**Basic Picture and Drawn pictures**

A set of basic pictures are called as basic picture language and a set of drawn pictures are called as drawn picture language. The basic classes and drawn classes of picture languages are conformed with basic Chomsky hierarchy. Attached basic picture and attached drawn picture clubbed together is called as attached picture. Let \( \pi \) is four-letter alphabet(picture description alphabet) as \( \pi = l, r, u, d \). Every word on \( \pi \) is \( \pi \)-word. A set of drawn pictures are called as drawn picture language. Introduced the catenation and kleen closure operation on picture language. Roger (1989) has analysed the following types of pictures: The shift(\( sh \)) of a word \( w \) is denoted as \( sh(w) \). Then sum of this letters are called as \( sh(\lambda) = (0, 0) \) and drawn picture of \( w \) is denoted as \( dpic(w) \), basic picture of \( w \) is denoted as \( bpic(w) \). A pair \( (p, e) \), where \( p \) is a edge and \( e \) is a vector. It is defined as: \( dpic(\epsilon) = (0, 0) \). A drawn picture \( q = (p, e) \), vector point \( e \) is called as end point.

**Symbolic picture and a drawn symbolic picture**

Gennaro et al. (2004) have suggested the expressive power of the drawn symbolic and symbolic picture languages by comparing the expressive power of the drawn symbolic and picture languages. A MIIs the universal line set and it is defined as a connection of lines of length 1 and it is going to end with...
M0(*Universal point set*). A drawn picture(q) is a triple, q = (b, s, e), where b is a connected finite subset of M1, s is a starting point(0, 0), e is ending point of drawn picture q. There are two conditions on b is given below,

1. if b is nonempty then s: & are points in w(q) ={v ϵ M0|{v, v’}}.
2. if b is empty, then s = e = (0, 0).

So empty drawn picture is denoted as (ϕ, (0, 0), (0, 0)).

**Recognizable Picture Languages**

A picture language is recognizable if it is an image of a local picture language under some alphabet projection. Let take the set of all pictures over a, b, in which the set of a-position is connected as recognizable. Same-wise, the set of b-position is connected as recognizable Matz (2006). Matz (2006) is proved that a picture language is not recognizable and also he proved that the picture language is both star free and piecewise testable. Let’s take Σ is a finite alphabet, set of all pictures over Σ is Σ**. A set of all the pictures over Σ and its size is (m, n) is denoted as Σn,m. A picture over Σ# is called as (n+2)(m+2) where # is a special symbol.

A three directions online tessellation automata are used for recognizing hexagonal picture languages. The hexagonal picture language over Σ with all sides of equal length is recognizable but not local. Here K. S. Dersanambika et al. (2003) have used different formalism for hexagonal picture languages. The formalisms are hexagonal tiling system, local hexagonal picture languages, recognizable hexagonal picture languages, labelled hexagonal Wang tiles and finally about Wang systems. Also they introduced about xyz-domino systems and proved that which is equivalent hexagonal tiling systems. Hexagonal patterns are used in picture processing with scene analysis. A review has done in both hexagonal pictures and hexagonal picture languages. A hexagonal picture is defined as p and its array of symbols is Γ. Let us consider a hexagonal pictures in figure 3 over the alphabet a, b, c, d. Hexagonal alphabet Γ and set of all hexagonal arrays over the hexagonal alphabet is Γ** then coordinates of this picture is shown in figure 4 with triangular axes x, y, z the coordinates.

**Hexagonal Pattern Languages**

K. S. Dersanambika et al. (2003) have defined that hexagonal pictures are used particularly in picture processing and also in image analysis. Ceterchi proposed variant for tissue like p-systems to generate the two-dimensional picture languages on the rectangular grids. This kind of p-system is generated to develop an initial and stable p-system. Always the hexagonal picture generation will start from top left corner. The analogous p-system with objects placed on triangular grids in the place of rectangular grid in the form of arrays and considered about the following hexagon shape-figure 2.
Hexagonal tiling system

Here K. S. Dersanambika et al. (2003) is mainly concentrated on local and recognizable hexagonal picture languages. A hexagonal tile over a hexagonal alphabet picture. A hexagonal picture (figure 5) is generated by using hexagonal tile over an alphabet a, ..., g. The family of hexagonal local picture languages is denoted by HLOC.

Definition: Let $\Gamma$ be a finite alphabet and a hexagonal picture language $L = \Gamma^* H$ is called local if there exists a finite set of $\Delta$ of hexagonal tiles over $\Gamma \cup \#$ such,

$\Delta = \{ \rho \in \Gamma^{*H} | B_{2,2,2}(\rho) \subseteq \Delta \}$

The language $L = L(\Delta)$ is a local hexagonal picture language. The hexagonal picture language over one letter alphabet with all sides of equal length is not local.

Collage Grammar

Generalization of graph grammars are called as collage grammar. In the same way, the sub pictures are directly substituted by another picture. Collage grammar was introduced by Habel, Kroowski and Taubenberger. Generalized iterated function system with rules of context-free types of tiles are considered for collage grammar. This process combines mathematical theory with its promising generative power, tilings to branching structures, modelling spectrum ranging from fractals, growing processes and finally about textures. Collage grammar is consisting coloured parts, also to decorate the collages with hyper edges that spans working areas. Finally refinement process is done in collage grammar. In this final process (refinement), by applying some rules, hyper edges are replaced by any other collages. So even if it is uni-coloured parts or simply shaped, using these processes we can get arbitrarily detailed and also multi-coloured pictures. Collage-One, a system which is used for implementing a collage grammar. This system helps to edit collage grammar in textually, graphically and evaluation of described derivation. Let's consider $X$ is a set, $p(\lambda)$ is power set of set $X$. The set of all finite sequences over $X$ is $X^*$, which includes empty string($\lambda$). Concatenation of $u$ and $v$ sequences are denoted as $u \cdot v$. An ordered sets $X, Y$ where the order is denoted as $\prec$, the complement of $X, Y$ denotes as $X \setminus Y$. The disjoint union of $X, Y$ is denoted as $X \cup Y$, where $x \prec y \forall x, y$. Collages The derivation process of collage grammar depends on hyper edge replacement. A productions $A \rightarrow R$, where $A$ is a label and $R$ is a collage. A set of productions are denoted as $P$. A composition of coloured parts and pin points are called as collages. A collage picture is obtained by covering the parts. Let's a fixed set of colours is denoted as COLOURS, $N$ be a labels.

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Kolam grammar

Kolam is a kind of a traditional art drawn in south India especially in Tamilnadu, one of the states of India. It decorates house courtyards and temples which is drawnin the early morning mainly by women. In olden days women are used to draw the kolams using rice flour and during festivals and weddings, rice flour paste is used instead of the flour. But nowadays limestone powder is used and during festivals colour powder is used. This tradition of drawing kolam is followed from generation to generation. In general dots are drawn first on the floor and then depending on the type of kolam, lines are drawn either linking the dots or going about the dots. The patterns in which lines are drawn around the dots are called as kambi kolams. The notable characteristic of this kambi kolam is that it can be drawn within a single stroke. Kiwamu Yanagisawa and Shojiro Nagata (2007) have analyzed the characteristics of designing system of kolam patterns in various aspects by using a method of converting these patterns into linear diagrams and numbers. While converting these patterns into numbers all the kolam patterns in figure 7. The Kolam pattern scan be expressed with hexadecimal numbers means that they can consist of 16 types of units in figure 8. They have discussed various drawing methods to create a new kolam. Although there are various styles of kolam, they have focused on string knot kolam called as kambi kolam.
Timothy M. Waring (2012) has presented the various types of kolams. The author implements an expanded sequential gestural lexicon for square loop kolams (SLK), and explains a system for the digitization of SLK patterns using this expanded and expandable language. He classified kolam patterns into five such as spiral kolam, radial kolam, tessellated kolam, hexagonal loop kolam and square loop kolam which is shown in figure 9.

**Figure 9:** types of kolams

The spiral kolam displays radial symmetry, and is constructed on a star of dots, and drawn as a single line. The kolams drawn with both orthogonally and hexagonally packed dot matrices. The family of kolam that has drawn the greatest academic attention is the show radial proportion, and do not require an initial dot matrix is called as radial kolam patterns namely pu kolam or rangoli. The tessellated kolam, in which individual line segments or short arcs connect the dots directly, is forming a tiled image. Tessellated kolam are dloop which is classified into hexagonal loop kolam and square loop kolam which is shown in figure 9.

**Figure 8:** 16 constituent units of kolan patterns, corresponding to hexadimal numbers

**Conclusion**

The various results of different classes have been discussed. The fundamental analysis of Picture languages, Chain codes, Recognizable picture language, Kolam grammar, Collage grammar have been discussed.

**REFERENCES**

