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<td>Tomiyama, Kiyonobu; Arita, Tomokazu; Tsuchida, Kensei; Yaku, Takeo</td>
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京都大学
Application of Attribute edNCE Graph Grammars to Syntactic Editing of Tabular Forms

富山 聖宜 (Kiyonobu TOMIYAMA)†
土田 賢 (Kensei TSUCHIDA)†
有田 友和 (Tomokazu ARITA)†
夜久 竹夫 (Takeo YAKU)†

†日本大学文理学部応用数学科
Department of Applied Mathematics, Nihon University
{ tomiyama, arita, yaku }@am.chs.nihon-u.ac.jp
†東洋大学工学部情報工学科
Department of Information and Computer Sciences, Toyo University
kensei@eng.toyo.ac.jp

Abstract Tabular forms such as program specification forms [7] are naturally formalized by the attribute graphs [8], in which the attribute denotes locations of items and while the edge labels denotes relations between items. Documents of the tabular forms are represented by graph grammars (e.g., see [8]). Accordingly, a syntactic formalization of document editing provides the foundation for mechanical documentation.

In this paper, we deal with particular graph grammar HNGG [7] for program specification tabular forms. We formalize syntax directed editing methods by extension of the notion of Cornell Program Synthesizer[2] to attribute NCE graph grammars (cf.[4]).

Keywords Graph Grammars, Visual Programming, Software Development, Syntax Directed Editors

1 Introduction

Mechanical editing of tabular forms is one of the important issues in the software engineering methodology. The Cornell Program Synthesizer (CPS) is well-known and is often referred to as a structured and text-based editor which uses an attribute grammar successfully [2]. Tabular forms are represented by several different models (e.g., Pane represents them by [6]). We assigned each item in the tabular form to an attributed node. This assignment naturally represents the order of items and location of items in the tabular form. Since the number of items in the form is generally infinite and the order of items has some valid meaning, tabular forms are denoted by graph grammars [7]. Accordingly, the mechanical editing of tabular forms supposed to be executed by some syntactic editing methods.

In this paper, we consider a programming documentation Hiform as an example of the tabular forms. Hiform document is a collection of 17 types of the tabular forms and includes all items defined in the guideline in ISO6592 [3],[7]. Those tabular forms are represented by graphs. Figure 1 illustrates a Hiform form and its corresponding graph. This graph is constructed as follows: (1) A node label of graph shows the type of an item of a tabular form. (2) An edge label shows relations between items. 'lf' denotes the meaning of 'left of'. 'ov' denotes 'over'. 'in' denotes 'within'.

A mechanical processing of tabular forms supposed to be realized effectively by syntactic manipulation of graphs. In [7], the inner structure of each form in Hiform is defined by an attribute NCE graph grammar.

The purpose of this paper is to extend CPS mechanisms to graphs using results in [4][7] and to formalize a syntactic editing mechanism for graphs, in this connection some examples are given in consideration with software documentation tabular forms. Definition is made as to insertion in HNGG [8] so that a manipulation is validly executed by the confluence[5] of HNGG.

2 Preliminaries

We review context-free edNCE graph grammars [5], and an attribute NCE graph grammar [7].

2.1 edNCE Graph Grammars [5]

Let Σ be an alphabet of node labels and Γ an alphabet of edge labels. A graph over alphabets Σ and Γ is a 3-tuple \( H = (V, E, \lambda) \), where \( V \) is a finite nonempty set of nodes, \( E \subseteq \{(v, \gamma, w) \mid v, w \in V, v \neq w, \gamma \in \Gamma\} \) is a set of edges and \( \lambda : V \rightarrow \Sigma \) is a node labeling function.

2.1.1 Definition An edNCE graph grammar is a 6-tuple \( G = (\Sigma, \Delta, \Gamma, \Omega, P, S) \), where \( \Sigma \) is the alphabet of node labels, \( \Delta \subseteq \Sigma \) is the alphabet of terminal node labels, \( \Gamma \) is the alphabet of edge labels, \( \Omega \subseteq \Gamma \) is the alphabet of final edge labels, \( P \) is the finite set of productions and \( S \in \Sigma - \Delta \) is the
initial nonterminal. A production is denoted by the form $p : X \rightarrow (D, C)$, where $X \in \Sigma \Delta$, $D$ is a graph over $\Sigma$ and $\Gamma$, and $C \subseteq \Sigma \times \Gamma \times \Gamma \times V_D \times \{in, out\}$ is connection relation.

2.2 Composition of Production Copies [4]

The composite representation of the production copies of an edNCE graph grammar is a theoretical and practical method for representing the graph-rewriting rules for embedding subgraphs of desired structures into a graph.

2.2.1 Definition[4] Let $G = (\Sigma, \Delta, \Gamma, \Omega, P)$ be an edNCE graph grammar. Let $p_1 : X_1 \rightarrow (D_1, C_1)$ $(D_1 = (V_{D_1}, E_{D_1}, \lambda_{D_1}))$ and $p_2 : X_2 \rightarrow (D_2, C_2)$ $(D_2 = (V_{D_2}, E_{D_2}, \lambda_{D_2}))$ be production copies of $G$. If $u \in V_{D_1}$, $X_2 = \lambda_{D_1}(u)$, and $D_1$ and $D_2$ are disjoint, then a composite production copy (with a connection relation) $p : X_1 \rightarrow (D_1, C_1)[u/(D_2, C_2)]$

The composite production copy $p$ composed by $p_1$ and $p_2$, and denoted by $p_1 \circ p_2$.

2.3 Confluence Property [5]

The confluence property guarantees that the result of a derivation shall not depend on the order of the left applications of the production copies. Confluence is a very important property because it guarantees the validity of the left application of the composite production copies. The confluence is also important in the case of developing efficient parsing algorithms.

2.3.1 Definition [5] An edNCE graph grammar $G = (\Sigma, \Delta, \Gamma, \Omega, P, S)$ is dynamically confluent if the following holds for every intermediate graph $H$ generated by $G$:

if $H \Rightarrow u_1, p_1 \Rightarrow u_2, p_2 \Rightarrow H_{12}$ and $H \Rightarrow u_3, p_3 \Rightarrow u_4, p_4 \Rightarrow H_{21}$ $(p_1, p_2 \in P)$ are (creative) derivation of $G$ with $u_1, u_2 \in V_H$ and $u_1 \neq u_2$, then $H_{12} = H_{21}$. 

2.4 Attribute NCE Graph Grammars [7]

We review an attribute graph grammar for the mechanical drawing. An attribute NCE graph grammar is as follows.

2.4.1 Definition [7] An attribute NCE Graph Grammar is a 3-tuple $AGG = \langle G, Att, F \rangle$ where $G = (\Sigma, \Delta, \Gamma, \Omega, P, S)$ is context-free edNCE graph grammar, called an underlying graph grammar of AGG. $Att$ is the set of attributes of AGG. $F$ is the set of semantic rules of AGG.

2.5 HNGG [7] [8] [9]

In this section, we consider an attribute NCE graph grammar. The grammar is called Hform Nested tabular form Graph Grammar (HNGG). $HNGG = \langle G_N, A_N, F_N \rangle$ that generates modular tabular forms called Hform form. Each production has attribute rules for drawing information. The HNGG includes 280 productions and 1248 attribute rules. Figure 2 illustrates a part of productions with attribute rules of HNGG.

3 Editing of Modular Tabular Form

In this section, we deal with a formal definition for editing manipulation using production instance of HNGG, and we also show the validity of our definition using confluence of HNGG.

3.1 Production Instance

We introduce editing manipulations in latter part. The editing manipulations are exactly defined by production instance as follows. In this part, we introduce production instance.
3.1.1 Definition A production instance ("instance" for short) is a 3-tuple \((\omega, p_i, H'_p)\), where 1. \(\omega \in V_{p_{i-1}}\) is a node removed during the derivation \(D_{i-1} \Rightarrow p_i, D_i\). 2. \(p_i : X_{p_i} \rightarrow (H_p, C_p) \in P\) is a production. 3. \(H'_p\) is an embedded graph isomorphic to \(H_p\), during \(D_{i-1} \Rightarrow p_i, D_i\).

We denote \(D_{i-1} \Rightarrow p_i, D_i\) if \(D_{i-1}\) is directly derived \(D_i\) by applying the instance \((\omega, p_i, H'_p)\).

If there is a production sequence \(p = (p_1, \ldots, p_n)\) and instance \((\omega_i, p_i, H'_p)\) for each production \(p_i\) (1 \(\leq i \leq n\)), an instance sequence is a sequence of \(((\omega_1, p_1, H'_p), \ldots, (\omega_n, p_n, H'_p))\).

3.2 Syntactic Insertion

In this part, we define the syntactic insertion, and denote the flow of insertion manipulation. This manipulation is based on HNGG. Syntax directed editing is executed by sequences of production instances.

3.2.1 Definition For a derivation sequence \(D_0 \Rightarrow p_1, \ldots, \Rightarrow p_{i-1}, D_{i-1} \Rightarrow p_i, D_i \Rightarrow p_{i+1}, \ldots, D_n\) with instance \((p_j : X_{p_j} \rightarrow (H_p, C_p), 1 \leq j \leq n)\), we say that \(q\) is insertable (for \(p_i\)) if there is an instance (\(\omega, q, H'_q\)) \((q : X_q \rightarrow (H_q, C_q) \in P_N)\) such that \(D_{i-1} \Rightarrow p_i, Q\) and if there is a derivation sequence \(D_{i-1} \Rightarrow q, D_i' \Rightarrow p_{i+1}, \ldots, D_n'\) with instance.

3.2.2 Definition For a production \(q : X_q \rightarrow (H_q, C_q) \in P_N\) which is insertable for \(p_i : X_{p_i} \rightarrow (H_p, C_p)\) and \(\bigcup_{i} H'_p \cap H'_q = \phi\), an instance sequence \(S\) is obtained by insertion of an instance \((\omega, q, H'_q)\) into an instance sequence \(((\omega_1, p_1, H'_p), \ldots, (\omega_n, p_n, H'_p))\).

\[
S = (\omega_1, p_1, H'_p), \ldots, (\omega_{i-1}, p_{i-1}, H'_{p_{i-1}}), (\omega_i, q, H'_q), (\omega_{i+1}, p_{i+1}, H'_{p_{i+1}}), \ldots, (\omega_n, p_n, H'_p))
\]

There is the instance sequence \(S\) as follows.

1. Trace the derivation sequence with instance \(D_n\) back to \(D_{i-1}\).
2. Apply the instance \((\omega, q, H'_q)\) to \(D_{i-1}\), and obtain the resultant graph \(Q\).
3. Apply the instance sequence \(((\omega_i, p_i, H'_p), (\omega_{i+1}, p_{i+1}, H'_{p_{i+1}}), \ldots, (\omega_n, p_n, H'_p))\) to \(Q\), and get the resultant graph \(D'_{i-1}\).

Inserting some instances into an instance sequence bring a new item into existence. That is, they correspond to a manipulation to insert a new item into a permissible place in a Hiform document.

3.2.3 Remark In the same manner as the editing by the instance for a production, we can further define insertable by composite production copy.

3.2.4 Definition A graph \(H'\) is obtained by syntactic insertion of a graph \(A\) at an edge \(x\) in a graph \(H\).

1. A composite production copy \(q\) for the graph \(A\) and the edge \(x\) exists. Furthermore, there exists an instance sequence \(i_q\) for \(q\) and \(x\).
2. There exists an instance sequence \(i_H\) for \(H\). An instance sequence \(S\) is obtained by insertion of \(i_q\) into an instance sequence of \(i_H\).
3. The graph \(H'\) is derived by the instance sequence \(S\).

3.2.5 Proposition Let \(H\) be the graph obtained from \(G\) by the insertion of nodes \(a\) and \(b\) at an edge \(x\) and an edge \(y\) respectively in this order, in HNGG. Let \(H'\) be the graph obtained from \(G\) by the insertion of nodes \(b\) and \(a\) at the edge \(y\) and \(x\) respectively in this order, in HNGG. Then, \(H = H'\).

3.2.6 Proposition Insertion in HNGG is executed in linear time.

We illustrate an example of an insertion based on HNGG by Figure 3. Here, we consider to insert a form \(F_2\) into a form \(F_1\). Let \(G_1\) be a graph for \(F_1\), and let \(G_2\) be a graph for \(F_2\). Then, a syntactic insertion of \(G_2\) at an edge \(e\) in \(G_1\) is done as following:

1. By \(e\) and \(G_2\), a composite production copy \(q\) for \(G_2\) is obtained. By \(q\) and \(e\), an instance sequence \(i_q\) is also obtained.
2. An instance sequence \(i_{G_1}\) is existed. If \(q\) is insertable for \(p\) in \(i_{G_1}\), an instance sequence \(i_q\) is obtained by insertion of \(i_q\) into an instance sequence \(i_{G_1}\).
3. By this instance sequence $i_G$, a graph $G$ is obtained. $G$ is a new form which is obtained by inserting $F_2$ into $F_1$.

4 Conclusion

We proposed editing method for tabular forms, based on attribute NCE graph grammar of tabular forms with a homogenous cell size. Our editing method also includes attribute rules for mechanical drawing. By using this editing method, we can exactly edit valid tabular forms defined by edNCE graph grammar. Linear time editing algorithm with attribute rules for primitive drawing exists.

These syntactic editing methods could be applied to syntactic manipulation of spreadsheet languages. We are reconstructing attribute rules for more sophisticated drawing. We are investigating other edit manipulations that are a division manipulation, a combination manipulation and so on. Furthermore we are now developing a tabular form editor system by using this approach.

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