

表編集のアルゴリズム

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Algorithms for Table Transformation

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Abstract:

Tables with heterogeneous cells are commonly used in computer human interface and documentation. We proposed an attribute multi edge graph representation for tables that considers editing and drawing in [7]. In this paper, we give algorithms for basic operations in table editing.

We provide a cell unification algorithm that runs in $O(1)$ time. We also provide a column insertion algorithm that runs in $O(n + m)$, for $n \times m$ heterogeneous tables. It is noted that the column insertion algorithm runs in $O(\sqrt{N})$ time for $N = n \times n$ cell square tables. while known methods require $O(N)$ time

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Keywords: Data structures and algorithms, graphs, table interface

1 Introduction

In this paper, we deal with the representation of tables while considering editing and drawing. Several representation methods have been proposed for tables: rectangular duals of planar graphs [1], and quadrees [3]. Although, we do not know which representation method is used in present table processing systems.

In this paper, we consider another graph representation [7] for tables, in which the table editing is executed efficiently. For drawing and editing problems, see [4, 5].

*This paper partly appeared in our previous study Tomoe Motohashi, Kensei Tsuchida and T. Yaku, Algorithm on attribute graphs for table editing, The 3rd Hungarian-Japanese Sumpos. Discrete Math. & Its Appl. and [6].

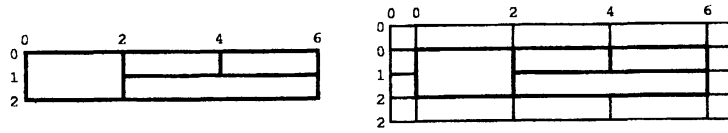


Figure 1: A: A Tabular Diagram D_1 B: A Tabular Diagram D_{1p}

In Section 2, we propose a representation of tables by an attribute multi edge graph. Several properties of the graphs are shown. In Section 3, we show several algorithms that execute table editing based on the representation. We provide algorithms for unifying cells, changing column width, and insertion column. Section 4 provides conclusions.

2 ATTRIBUTE GRAPHS FOR TABLES

We described several definitions concerning tables in [7]. We represent a table by a certain type of tabular diagram satisfying Condition 2.1 in [7]. That is, the tabular diagrams have perimeter cells.

Example 2.1 Figure 1A illustrates a tabular diagram $D_1 = (T_1, P_1, g_1)$, where $P_1 = \{(1, 1), (2, 1)\}, \{(1, 2)\}, \{(1, 3)\}, \{(2, 2), (2, 3)\}$ is a partition over a $(2, 3)$ -table T_1 . A grid g_1 is defined by $g_{1row}(0) = 0, g_{1row}(1) = 1, g_{1row}(2) = 2$, and $g_{1column}(0) = 0, g_{1column}(1) = 2, g_{1column}(2) = 4$, and $g_{1column}(3) = 6$. For a cell $c = \{(2, 2), (2, 3)\}$, we define the north wall $nw(c) = g_{1row}(1) = 1$, south wall $sw(c) = g_{1row}(2) = 2$, east wall $ew(c) = g_{1column}(3) = 6$, and west wall $ww(c) = g_{1column}(1) = 2$. Figure 1B illustrates a tabular diagram D_{1p} with perimeter cells. For the table drawing, it corresponds to D_1 .

Now, we introduce an attribute graph. Then, we show how to represent a tabular diagram as an attribute graph.

Definition 2.1 An *attribute graph* is a 6-tuple $G = (V, E, L, \lambda, A, \alpha)$, where (V, E) is a *multi-edge undirected graph*, L is the set of *labels* for edges, $\lambda : E \rightarrow L$ is the *label function*, A is the set of *attributes*, and $\alpha : V \rightarrow A$ is the *attribute map*.

A tabular diagram $D = (T, P, g)$ is *represented* as an attribute graph $G_D = (V_D, E_D, L, \lambda_D, A, \alpha_D)$, where V_D is identified by a partition P (we denote a node corresponding to a cell c in P by v_c , we call v_c a *perimeter node* (resp. *inner node*) if c is a perimeter cell (resp. inner cell)), E_D is defined by Rules 1-4, $L = \{enw, esw, eew, eww\}$, $\lambda_D : E_D \rightarrow L$ is defined by Rules 1-4, $A = R^4$, and $\alpha_D : V_D \rightarrow R^4$ are defined by $\alpha_D(v_c) = (nw(c), sw(c), ew(c), ww(c))$.

Rule 1 If $nw(c) = nw(d)$ and there is no cell between c and d having an equal north wall, then $[v_c, v_d]$ is in E_D and $\lambda_D[v_c, v_d] = enw$. In this case, $[v_c, v_d]$ is called a *north wall edge*. Similarly, **Rules 2, 3** and **4** define the *south wall*, *east wall*, and *west wall edges*, respectively.

An attribute graph G_D is called a *tessellation graph*. Note that the degree $\#v$ of each node v in G_D is at most 8. The location values of the inner cells are evaluated from the location values of perimeter cells and linked edges. So, we assume in the latter part of this paper, that the α_D values of the inner cells are null.

Note that we consider tabular diagrams with perimeter cells. Then,

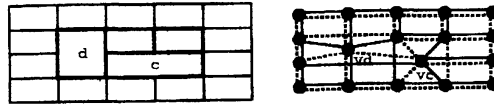
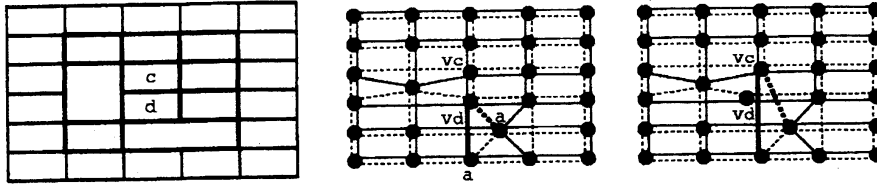


Figure 2: Tabular Diagram and Its Corresponding Tessellation Graph

Figure 3: Change of Vertical Edges of v_d

Proposition 2.1 Let G_D be a tessellation graph for a tabular diagram D of an (n, m) -table. Let k be the number of inner cells in G_D . For the number $\#E_D$ of edges in G_D , we have $2\#E_D = 6(2n - 4) + 6(2m - 4) + 8k + 16$.

3 ALGORITHMS

This section provides algorithms for tessellation graphs. The following algorithm execute unification of two adjacent inner cells in the tabular diagram.

ALGORITHM UNIFYCELLS(G_D, v_c, v_d, G_E)

INPUT

$G_D = (V_D, E_D, L, \lambda_D, A, \alpha_D)$: a tessellation graph for a tabular diagram D , v_c : a node in G_D corresponding to an inner cell c , v_d : a node in G_D corresponding to an inner cell d which is adjacent to the south wall of c that is $ww(c) = ww(d)$, $ew(c) = ew(d)$, $sw(c) = nw(d)$.

OUTPUT

$G_E = (V_E, E_E, L, \lambda_E, A, \alpha_E)$: a tessellation graph for a tabular diagram E , where E is obtained from D by the unification of cells c and d to c .

METHOD

begin

Initially let $G_E \leftarrow G_D$;

/* change of vertical edges concerning to d */

delete two vertical edges between v_d and $a (\neq v_c)$ from E_E ;

add edges between v_c and a to E_E ;

put $\lambda_E[v_c, a] \leftarrow \lambda_D[v_d, a]$;

delete two vertical edges between v_c and v_d from E_E ; (See Fig.3)

/* change of south wall edges concerning to c */

choose two nodes f and $f' (f \neq f')$ such that $\lambda_D[f, v_c] = \lambda_D[v_c, f'] = esw$;

delete south wall edges $[f, v_c]$ and $[v_c, f']$;

add an edge $[f, f']$ to E_E and put $\lambda_E[f, f'] \leftarrow esw$;

/* change of south wall edge concerning to d */

choose two nodes h and h' ($h \neq h'$) such that $\lambda_D[h, v_d] = \lambda_D[v_d, h'] = esw$;
 delete south wall edges $[h, v_d]$ and $[v_d, h']$;
 add $[h, v_c]$ and $[v_c, h']$ to E_E and put $\lambda_E[h, v_c] \leftarrow esw, \lambda[v_c, h'] \leftarrow esw$;
 /* change of north wall edges concerning to d */
 choose two nodes g and g' ($g \neq g'$) such that $\lambda_D[g, v_d] = \lambda_D[v_d, g'] = enw$;
 delete north wall edges $[g, v_d]$ and $[v_d, g']$ from E_E ;
 add an edge $[g, g']$ to E_E and put $\lambda_E[g, g'] \leftarrow enw$;
 delete a node d
end.

Theorem 3.1 *Let D be a tabular diagram, and c be a cell in D . Suppose that there is an adjacent cell d at south side in D such that $ew(c) = ew(d)$, $ww(c) = ww(d)$ and $sw(c) = nw(d)$. Let E be a tabular diagram obtained from D by the unification of cells c and d to c . Let G_D and G_E be the tessellation graphs for D and E , respectively. Then G_E is obtained from G_D in constant time.*

Theorem 3.2 *Let D be a tabular diagram, and c be an inner cell in D . Let δ be a movement value. Suppose $\Delta + \delta > 0$, where $\Delta > 0$ is the width of a perimeter cell in the column which has equal east wall to c . Let E be a tabular diagram obtained from D by the changing width using δ of cells that have the equal east wall for c . Let G_D and G_E be the tessellation graphs for D and E , respectively. Then G_E is obtained from G_D in $O(n + m)$ time by the algorithm CHANGECOLUMNWIDTH [6], where n is the number of rows in D .*

The following algorithm executes insertion of a column at the west side of a focused cell into the tabular diagram.

ALGORITHM INSERTCOLUMN(G_D, v_c, G_E)

INPUT

G_D : a tessellation graph for a tabular diagram $D = (T, P, g)$, v_c : a node in G_D corresponding to a cell c , where the cell, that is adjacently located at the west-side of c , exists.

OUTPUT

G_E : a tessellation graph for E , where E is a tabular diagram obtained from D by insertion of a column with width δ at the west side of c , where δ is the width of a perimeter cell in the column including c .

METHOD

begin

Initially, put $G_E \leftarrow G_D$;

traverse upward through the west wall edges from v_c until a perimeter node v_0 (see Fig.5) ;

let δ be the width of the cell corresponding to v_0 ;

add a node u_0 ;

put $i \leftarrow 0$;

/* insert a column */

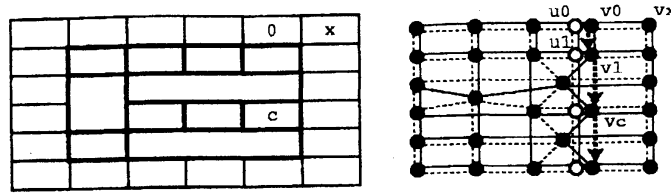
while a node v_i is not the lowermost node **do begin**

let w_i be an adjacently west-side node linked to v_i by a north wall edge ;

delete the north wall edge between w_i and v_i ;

add a north wall edge between w_i and u_i ;

deform G_E similarly for a south wall edge ;

Figure 4: Insertion of the Column at the West-Side of c

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add a north wall edge and south wall edge between  $u_i$  and  $v_i$  ;
let  $v_{i+1}$  be a lower node linked to  $v_i$  by a west wall edge ;
add a node  $u_{i+1}$  ;
add a west wall edge and east wall edge between  $u_i$  and  $u_{i+1}$  ;
 $i \leftarrow i + 1$ 
end ; (see Fig.6)
deform  $G_E$  for the lowermost node  $v_i$ , similarly for the north and south wall edge;
/* the existing column shifts to the east */
let  $u_0$  be the uppermost node in  $u_i$ 's ;
let  $v_x$  be adjacently west-side node linked to the node in the northeast corner in  $G_E$  ;
put  $G_{E_0} \leftarrow G_E$  ;
CHANGECOLUMNWIDTH( $G_{E_0}, v_x, \delta, G_E$ ) ;
put  $G_{E_0} \leftarrow G_E$  ;
let  $x_0$  be a node adjacently west-side of  $v_x$  ;
put  $i \leftarrow 0$  ;
while  $ww(u_0) \leq ww(x_i)$  do begin
    MOVEEASTWALL( $G_{E_i}, x_i, \delta, G_{E_{i+1}}$ ) ;
    let  $x_{i+1}$  be an adjacently west-side node linked to  $x_i$  by a north wall edge ;
    put  $i \leftarrow i + 1$  ;
end ;
put  $G_E \leftarrow G_{E_i}$  ;
end.

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Theorem 3.3 Let D be a tabular diagram, and c be a cell in D . Suppose that E is the tabular diagram obtained from D by insertion of a column with width δ at the west side of the column including c , where δ is the width of a perimeter cell of the column including c . Let G_D and G_E be the tessellation graphs for D and E , respectively. Then G_E is obtained from G_D in $O(n + m)$ time, where n and m are the number of rows and columns in D , respectively.

It is noted that the column insertion algorithm runs in $O(\sqrt{N})$ time for $N = n \times n$ cell square diagrams. while known methods require $O(N)$ time. The following table illustrates the features of representation methods for N cell square tables with respect to the column insertion.

Model	Node degrees	Cell to node relation	Cell visits	Complexity
Quadtrees [1]	at most 5	one 'block' to one node	at most N	$O(N)$
Rec-tangular dual graphs [2]	at most $4N$	one cell to one node	at most N	$O(N)$
Tessellation graphs	at most 8	one cell to one node	at most $2\sqrt{N}$	$O(\sqrt{N})$

4 CONCLUSION

We introduced attribute graphs and algorithms for table drawing and editing. We note that, we have determined the necessary and sufficient condition where an attribute graph represents a tabular diagram by a graph grammar. [9]. We are designing a processing system for table editing based on our model in [8].

The authors thank to Prof. Tominaga of Tokyo University of Technology for valuable discussion with him.

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