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A Study of an Event Oriented Data Management Method for Displaying Genealogy: Widespread Hands to InTErconnect BASic Elements (WHIteBasE)

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Abstract: **In this paper, we propose a new data management method for handling relations on genealogy display software easily. It is named "Widespread Hands to InTErconnect BASic Elements (WHIteBasE)". The WHIteBasE is a hidden node for integrating the relations due to an event including a married couple and their children. That is, individual's data does not refer to others directly, and only refers to WHIteBasEs. As a result, the number of references is less than the existing data structure. Therefore, the volume of database is smaller, the complex multiple marriages can be set easily, and the positions of the segment intersections can also be searched easily. Then, displaying genealogy like a traditional handwriting style can be achieved on computers. Our new prototype software and the effectiveness of our method are shown.**

Keywords: Genealogy, Hidden Node, Segment Intersections, Search Algorithm, Free Layout, Intuitive Graphical Editor

I. Introduction

A. Required genealogy display style

Genealogy has been written on paper media from ancient times. An example of the genealogy is shown in Fig. 1 [1]. This style (including Japanese traditional handwriting style*) has four features as follows:

*In Japan, a double segment is used for connecting to a married couple, and a horizontal segment is used for connecting to brothers and/or sisters.

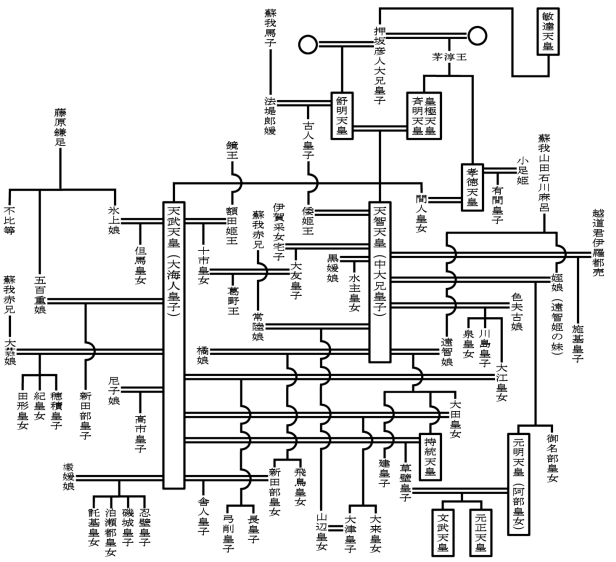


Figure. 1: An example of genealogy with segment intersections on paper media showing a family of old Japanese emperors by using KANJI and HIRAGANA that are Japanese language (Modified from [1])

- One individual is generally written only once.
- Many individuals are placed in the free positions as the users' requirement.
- Horizontal and/or vertical segments are mainly used.
- Segment intersections are used if necessary.

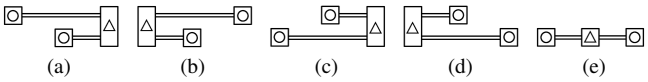


Figure. 2: Marriage with two wives

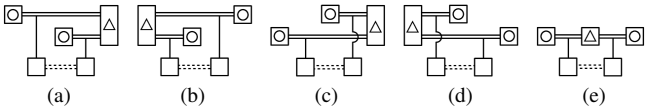


Figure. 3: Marriage with two wives who have a child

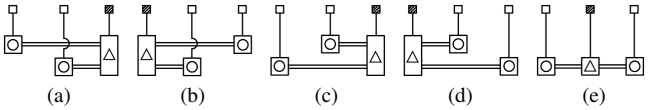


Figure. 4: Marriage with two wives and their parents

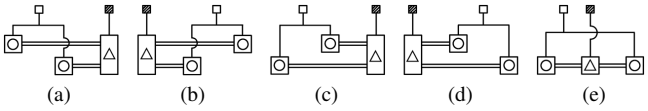


Figure. 5: Marriage with two wives who are sisters and their parents

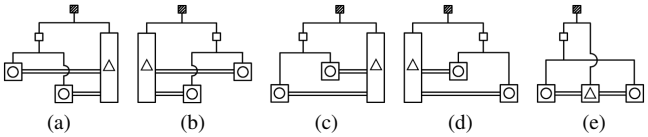


Figure. 6: Marriage with two wives who are niece sisters

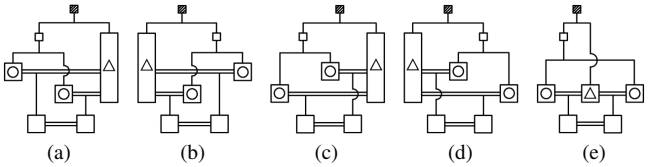


Figure. 7: Marriage with two wives who are niece sisters and have a child

That is, many arcs are found on the cross points between the vertical segments and the horizontal segments. These arcs give the users the impression that the users can find the intersecting points of two segments on the 2D figure. Some rectangles of individuals are written in large so that they can connect many individuals by using many segments.

Using this style, the users can, at a glance, understand the information of an individual, and also the complex relations with others. However, it is difficult to write the relations by traditional handwriting (without software), and it takes a lot of time for the data input even if using software. Therefore, many users in Japan expect the use of the genealogy display software with the style as shown in Fig. 1.

B. Minimum units of segment intersections

To achieve the requirements, we investigated where the segment intersections are generated [2], [3]. If a tree structure is only used, segment intersections do not occur. Otherwise, if a man with two wives is displayed, or two brothers with their wives are displayed, segment intersections will occur. We call them the minimum units of segment intersections. The numbers of segment intersections will be shown in each case.

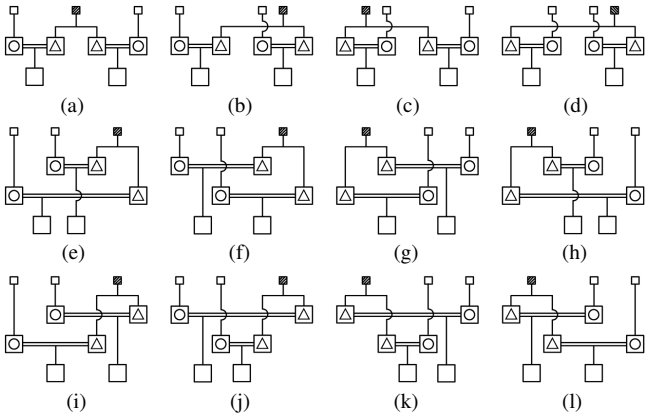


Figure. 8: Two brothers take their wives in marriage

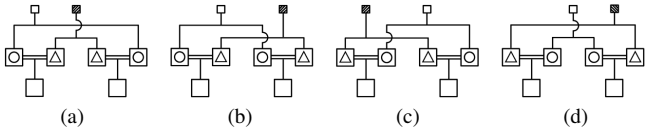


Figure. 9: Two brothers take their wives who are sisters in marriage (Kariera-type)

1) Marriage with Two Wives

There are six connecting types as the following:

- The cases of marriage with two wives are shown in Figs. 2(a)–(e) that have the differences of arrangement.
- The cases of marriage with two wives and their children are shown in Figs. 3(a)–(e). No intersection occurs in the cases of (a), (b), (e). However, an intersection occurs in the cases of (c), (d). The cases of marriage between a half-brother and a half-sister displayed with double-dotted segment is included in these figures.
- The cases of marriage with two wives and their parents are shown in Figs. 4(a)–(e). No intersection occurs in the cases of (c)–(e). However, an intersection occurs in the cases of (a), (b). "▨" is man's parent (ascendant), "□" is woman's parent (ascendant) of partner marriage.
- The cases of marriage with two wives who are sisters are shown in Figs. 5(a)–(e). No intersection occurs in the cases of (c), (d). However, an intersection occurs in the cases of (a), (b), (e).
- The cases of marriage with two wives who are niece sisters are shown in Figs. 6(a)–(e). These numbers of segment intersections are the same as Figs. 5(a)–(e).
- The cases both of marriage with two wives who are niece sisters and marriage between a half-brother and a half-sister who are children of two wives are shown in Figs. 7(a)–(e). An intersection occurs in all cases.

2) Marriages of Two Brothers and Their Wives

There are two connecting types as the following:

- The cases of marriage of two brothers and their wives are shown in Figs. 8(a)–(l). No intersection occurs in the case of (a). However, an intersection occurs in the cases of (b), (c), (e)–(i), (l) and two intersections occur in the cases of (d), (j), (k).
- The cases of Kariera-type, that is the marriage between two brothers and their wives who are sisters, are shown in Figs. 9(a)–(d). An intersection occurs in all cases.

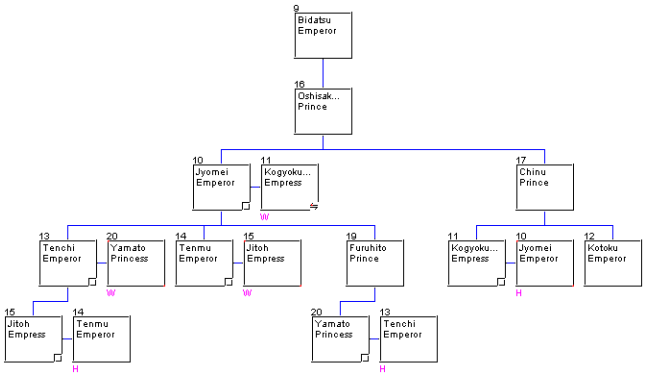


Figure. 10: Alliance [4]

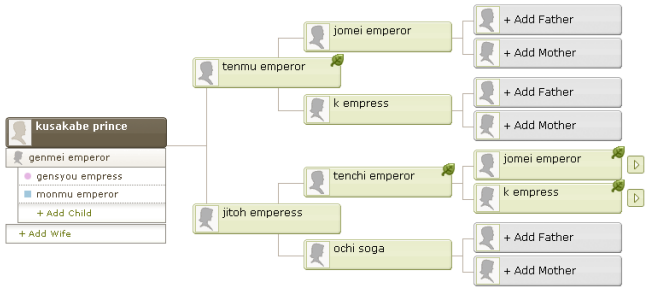


Figure. 11: Ancestry [5]

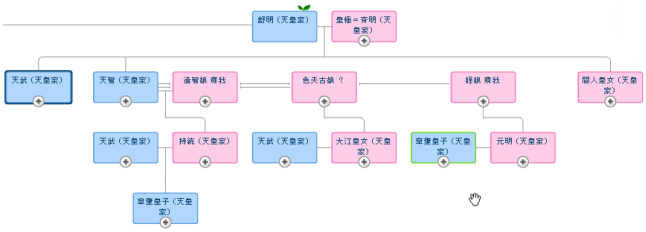


Figure. 12: myHERITAGE [6]

C. *Existing genealogy display software*

There is a lot of genealogy display software all over the world. However, there is no software that meets the requirements. The existence/nonexistence of segment intersections comes from the differences of the connecting types. How to display the complex families in existing software?

For example, on Alliance [4] as shown in Fig. 10, the IDs: 10, 11, 13, 14, 15 and 20 are displayed twice respectively though each ID is the same individual. That is, when a complex relation is written on the data table, one individual is always displayed in multiple places and this algorithm avoids to display the segment intersections. As a result, the users must imagine the restructured image of the complex relations though this is graphical display software. If using segment intersections, these individuals can be displayed only once and can be understood easily.

Ancestry (Fig. 11 [5]) and myHERITAGE (Fig. 12 [6]), the well-known existing genealogy display software, are similar to Alliance. They have no segment intersections and have the same problem too.

Madeline 2.0 PDE (Fig. 13 [7]) can display an individual twice with two symbols for avoiding segment intersections, and also, CraneFoot (Fig. 14 [8]) and PedNavigator [9] can. That is, however, it is clear that they also cannot display segment intersections and have the same problem too.

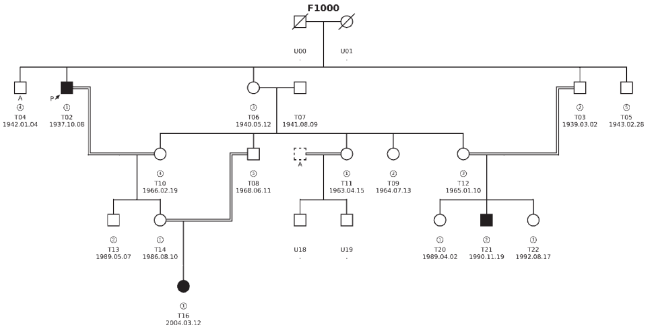


Figure. 13: Madeline 2.0 PDE [7]

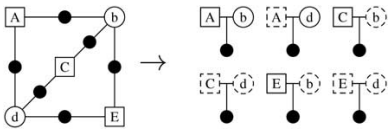


Figure. 14: CraneFoot [8]

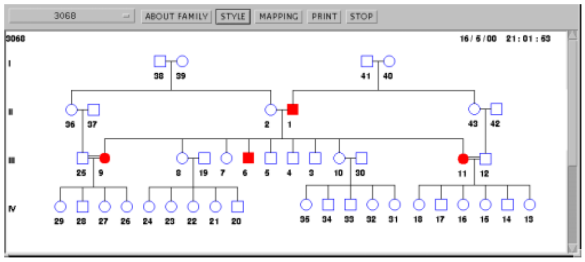


Figure. 15: An example of the algorithmic aspects [10]

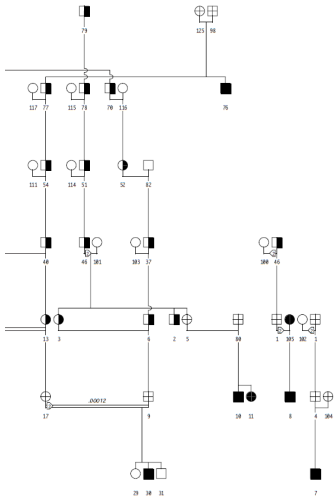


Figure. 16: Pedigree Draw [11]

The basic numerical research for avoiding segment intersections is found (Fig. 15 [10]). As already stated, however, displaying multiple marriages, segment intersections have to be used. It is insufficient only in this calculation.

Pedigree Draw (Fig. 16 [11],[12]) can display the genealogy by using segment intersections, and also there are some integrating programs for Pedigree Draw[13],[14]. However, this software has two problems. One is that the generation grids are used, and the individuals' locations of the vertical direction are fixed. Therefore, the users cannot write them in the free positions. The other is that the multiple marriages are displayed in two places. So, one individual cannot be located once. That is, this software has also the similar problem to Alliance.

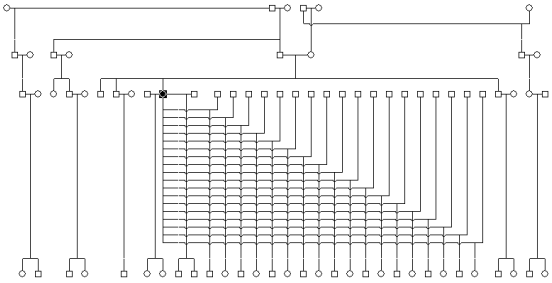


Figure. 17: PED Pedigree Software [15]

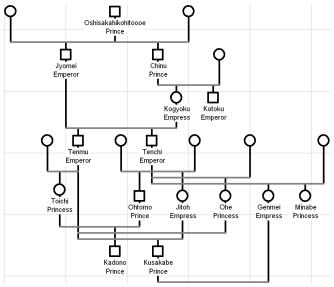


Figure. 18: GenoPro [16]

PED Pedigree Software (Fig. 17 [15]) can display segment intersections, however, these are only polygamy or polyandry for one generation. In addition, using the Edit Window that is another drawing mode, segment intersections have to be set in manual operations. So, this software cannot display all of the minimum unit of segment intersections automatically.

GenoPro (Fig. 18 [16]) can display the genealogy with free positions. However, complex relations cannot be connected freely. In addition, this software has the problem that the vertical segments and the horizontal segments are classified by using the different colors instead of using many arcs. And the different colors are similar like black and gray. Therefore, the display fails if it is printed only by monochrome binary.

It is often said that using 3D graphics is easy to construct the segment intersections than 2D. Fig. 19 shows a sample of 3D genealogy by Topic Map [17]. However, many names not only overlap but also their representation conceals the segments. The users cannot understand the relations because all segments cannot be seen at the same time. That is, 3D is rather more difficult to understand them than 2D. In addition, Celestial3D (Figs. 20(a),(b) [18]) can display 2D genealogy by transforming from 3D. However, segment intersections cannot be displayed in 2D. So, though using 3D, the method for displaying segment intersections in 2D is necessary.

M. Aida[19] researches the database for classical Japanese genealogy. However, the information of historical persons is mainly stored by the functions of the database, and it does not focus on displaying style of genealogy.

There is a standard both of symbols for denoting many types of individuals and segments for connecting them in genealogy according to each culture and/or each special field[20]. However, it is not trivial in many cases.

Thus, the existing genealogy display software does not meet the requirements. These kinds of differences make the users confused or felt uncomfortable to use them. Though a lot of researchers know the necessity of constructing segment intersections, why cannot they meet? We believe that there is a problem in the existing data structure.

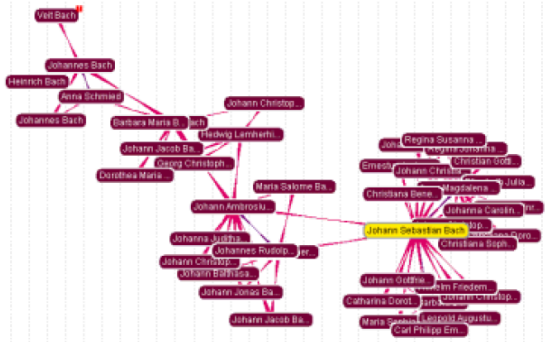
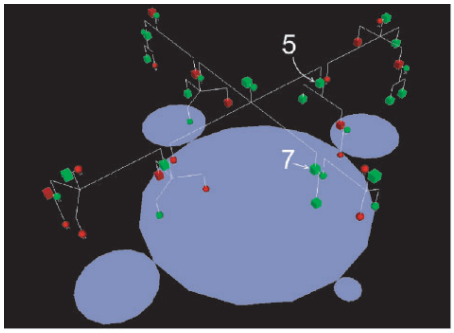
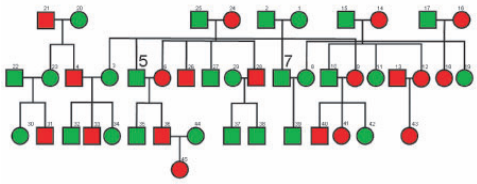


Figure. 19: Topic Map [17]



(a) 3D display



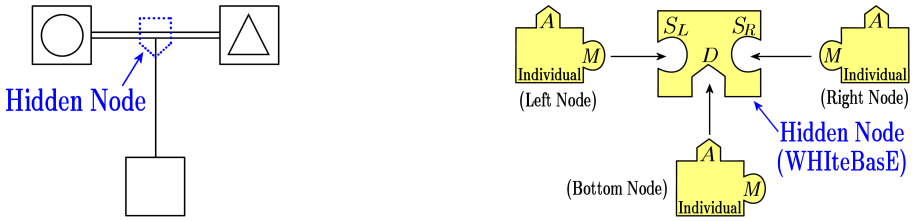
(b) 2D display

Figure. 20: Celestial3D [18]

GEDCOM [21] is a de facto standard for making data of genealogy. So, it is used in a lot of existing genealogy display software. However, the information of individuals and references to other individuals' IDs are only written in this format. An event of a family, including a relation between marriage of a couple and their children birth, is not written. Therefore, the complex relations cannot be displayed if software does not consider them. This is a reason why existing software is uncomfortable. The event should be managed directly in data structure.

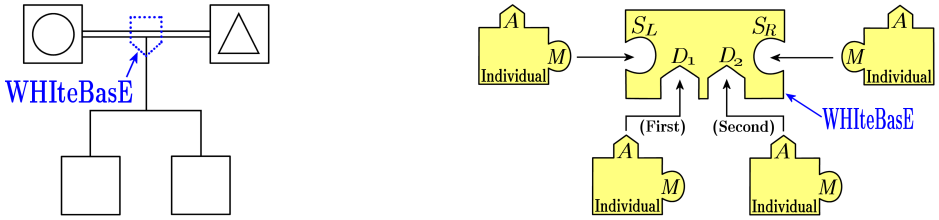
D. Purpose of our research

In this research, we propose a new data management method for handling relations so that genealogy display software can satisfy the requirements. It is named "Widespread Hands to InTErconnect BASic Elements (WHIteBasE)" [3]. A WHIteBasE is a hidden node for integrating a relation between a married couple and their children as an event. That is, individual's data does not refer to other IDs directly, and only refers to the WHIteBasE IDs. As a result, the number of references is less than the existing data structure. Therefore, the volume of database is smaller, the complex multiple marriages can be set easily, and the positions of the segment intersections can also be searched easily. Then, the requirements can be satisfied and WHIteBasE is benefit of cultural science.



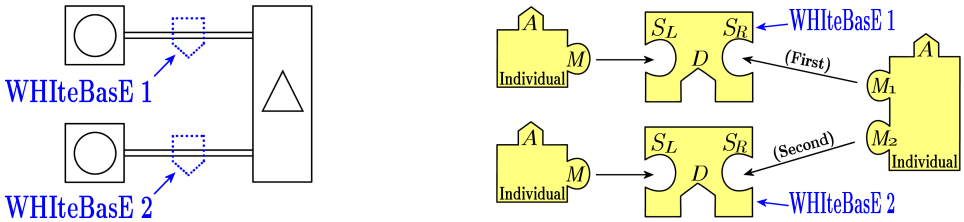
(a) Genealogy Style (b) Model of WHIteBasE

Figure. 21: A normal connection with a married couple and their child by using a Hidden Node (WHIteBasE)



(a) Genealogy Style (b) Model of WHIteBasE

Figure. 22: A normal connection with a married couple and their children by using a Hidden Node (WHIteBasE)



(a) Genealogy Style (b) Model of WHIteBasE

Figure. 23: A normal connection with Multiple Marriages by using plural Hidden Nodes (WHIteBasEs)

II. WHIteBasE

A. A model of WHIteBasE

1) Hidden Node

This is a new data management method. A relation between a married couple and their child is managed as an event by a Hidden Node (Fig. 21(a)). The Hidden Node can be displayed on the genealogy display area while the users input the data. Otherwise, it can be not-displayed when the genealogy is shown. The dotted pentagon is shown at the position of the Hidden Node for convenience in understanding the meaning of this management style.

2) WHIteBasE

A model of connections using the Hidden Node that manages the nodes of three individuals is shown in Fig. 21(b). It has three keyholes S_L, S_R and D. S_L, S_R (S means Substance) denote the keyholes for connecting two nodes of a married couple facing left and right, D (meaning Descendant) denotes the keyhole for connecting a node of a child facing down. The suffixes $_L$ and $_R$ are only denoted to connect to the Individual Nodes facing left and right of the Hidden Node respectively. The left and right, as an actual display position and the difference between a male parent and a female parent, are in any order.

The individual's Node (named the "Individual Node") has two keys A and M. A (meaning Ascendant) denotes the key of a parent facing up, and M (meaning Married) denotes the key of a marriage facing left or right. Note that the key M facing right and the key M facing left have the same meaning. These keyholes and keys only show the connection model. So, it is not necessary to imagine these pieces close together like a puzzle. The arrows can show the relations of connections between keyholes and keys. They can be connected to Individual Nodes on both sides very well. So, it is named "Widespread Hands to InTErconnect BASic Elements (WHIteBasE)". After this, the Hidden Node is called "WHIteBasE".

3) Brothers and Sisters

If children occur as shown in Fig. 22(a), the keyhole D of a WHIteBasE is extended in multiple keyholes D_j as shown in Fig. 22(b). The suffix j denotes the array counter for brothers and/or sisters. In this case, D_1 denotes the keyhole for connecting the first child and D_2 denotes the keyhole for connecting the second child. So, Individual Nodes of children can be connected to a WHIteBasE by using each key A. This WHIteBasE is located at the same junction as shown in Fig. 21(a).

4) Multiple Marriages

If multiple marriages occur as shown in Fig. 23(a), the key M of the Individual Node is extended in multiple keys M_k (Fig. 23(b)). After that, plural WHIteBasEs are used because it has only two keyholes for connecting marriage.

Note that many keyholes D_j and keys M_k are increasable according to additional children and additional multiple marriages respectively.

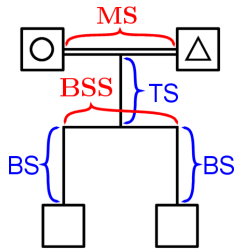


Figure. 24: Definition of segment names

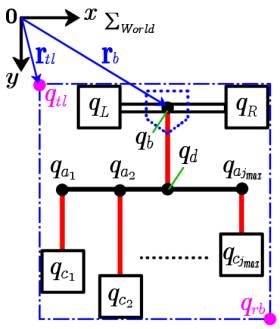


Figure. 25: Definition of coordinate system

5) Names of Segments

We define the names of four kinds of segments as shown in Fig. 24. The double horizontal segment MS is denoted a "Marriage Segment" for connecting a married couple, the vertical segment TS is denoted a "Trunk Segment" for connecting to the descendant segments, the horizontal segment BSS is denoted a "Brothers and Sisters Segment" for connecting children's segments, and the vertical segments BSs are denoted "Branch Segments" for branching each child. In addition, the WHIteBasE is installed at the junction between the MS and the TS.

B. Definition of WHIteBasE model

We define a model of WHIteBasE for generalizing in this paragraph. WHIteBasEs are defined by using a set W_i and Individual Nodes are defined by using a set I_j as shown in

$$\begin{array}{l} W_i = \{S_L, S_R, D_j, \mathbf{Q}\} \\ I_j = \{A, M_k\} \end{array} \quad \left\{ \begin{array}{l} i = 0, 1, \cdots, i_{max} \\ j = 0, 1, \cdots, j_{max} \\ k = 0, 1, \cdots, k_{max} \end{array} \right. \tag{1}$$

where i, j, k denote the IDs on the data table respectively, $i_{max}, j_{max}, k_{max}$ are the maximum values. S_L, S_R denote the IDs of two Individual Nodes (a couple) connected with the left and right sides of a WHIteBasE. D_j denotes the IDs of Individual Nodes (Children) connected with down side of a WHIteBasE. A denotes the ID of a WHIteBasE for handling of ascendant (Parent). M_k denotes the IDs of a WHIteBasE for handling of marriage.

The IDs of Individual Nodes are written on the data table for holding a name of an Individual, and its supplementary information. The IDs of WHIteBasEs are managed by a separated data table from the Individuals. And $\mathbf{Q}$ denotes the set of coordinate values of each position managed by a WHIteBasE (Fig. 25) and is denoted in

$$\mathbf{Q} = \{q_b, q_L, q_R, q_d, q_{a_j}, q_{c_j}, q_{tl}, q_{rb}\} \tag{2}$$

where q_b denotes the WHIteBasE's position, q_L, q_R denote the parents' positions, q_d denotes the junction's position between the MS and the TS, q_{c_j} denotes the children's positions, q_{a_j} denotes the junctions' positions between the BSS and the BS, q_{tl}, q_{rb} denote the positions of top-left and bottom-right of all area managed by a WHIteBasE.

$\mathbf{Q}$ are written on the coordinate system $\sum_{world}$ measured from the origin of the displaying area. For example, $\mathbf{r}_{tl}$ denotes the position vector to q_{tl}, $\mathbf{r}_b$ denotes the position vector to q_b, and so on. $(x_{i,tl}, y_{i,tl})$ denote the position of q_{tl}, $(x_{i,b}, y_{i,b})$ denote the position of q_b and so on for showing the position of each W_i, and they are used for comparing the positions of different WHIteBasEs.

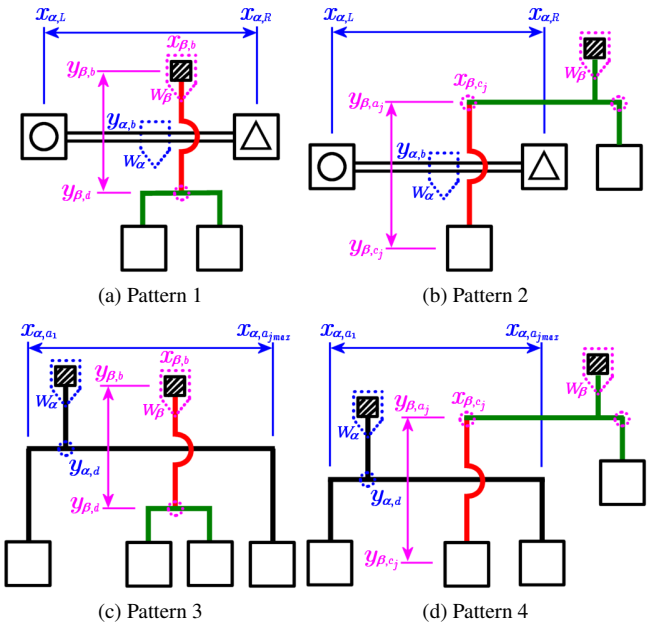


Figure. 26: Search pattern of segment intersections

III. Search Method of Segment Intersections

A. Search algorithm

Genealogy can be displayed by using two types both of horizontal segments and vertical segments, if following the rule of displaying genealogy described in paragraph I-A. The horizontal segments are only two types of the MS and the BSS. The vertical segments are only two types of the TS and the BS. These horizontal segments and vertical segments do not intersect at all on a WHIteBasE (Refer Figs. 24). That is, if using two or more than three WHIteBasEs, it is necessary to search the segment intersections.

For this reason, the search algorithm for comparing two WHIteBasEs α and β uses two horizontal segments and two vertical segments. In short, they have four patterns and they can be classified as follows:

(a) The MS of W_α and the TS of W_β are crossing as shown in Fig. 26(a).
If $x_{\alpha,L} < x_{\beta,b} < x_{\alpha,R}$ and $y_{\beta,b} < y_{\alpha,b} < y_{\beta,d}$, then, the coordinate of intersection is $(x_{\beta,b}, y_{\alpha,b})$.

(b) The MS of W_α and the BS of W_β are crossing as shown in Fig. 26(b).
If $x_{\alpha,L} < x_{\beta,c_j} < x_{\alpha,R}$ and $y_{\beta,a_j} < y_{\alpha,b} < y_{\beta,c_j}$, then, the coordinate of intersection is $(x_{\beta,c_j}, y_{\alpha,b})$.

(c) The BSS of W_α and the TS of W_β are crossing as shown in Fig. 26(c).
If $x_{\alpha,a_1} < x_{\beta,b} < x_{\alpha,a_{j_{max}}}$ and $y_{\beta,b} < y_{\alpha,d} < y_{\beta,d}$, then, the coordinate of intersection is $(x_{\beta,b}, y_{\alpha,d})$.

(d) The BSS of W_α and the BS of W_β are crossing as shown in Fig. 26(d).
If $x_{\alpha,a_1} < x_{\beta,c_j} < x_{\alpha,a_{j_{max}}}$ and $y_{\beta,a_j} < y_{\alpha,d} < y_{\beta,c_j}$, then, the coordinate of intersection is $(x_{\beta,c_j}, y_{\alpha,d})$.

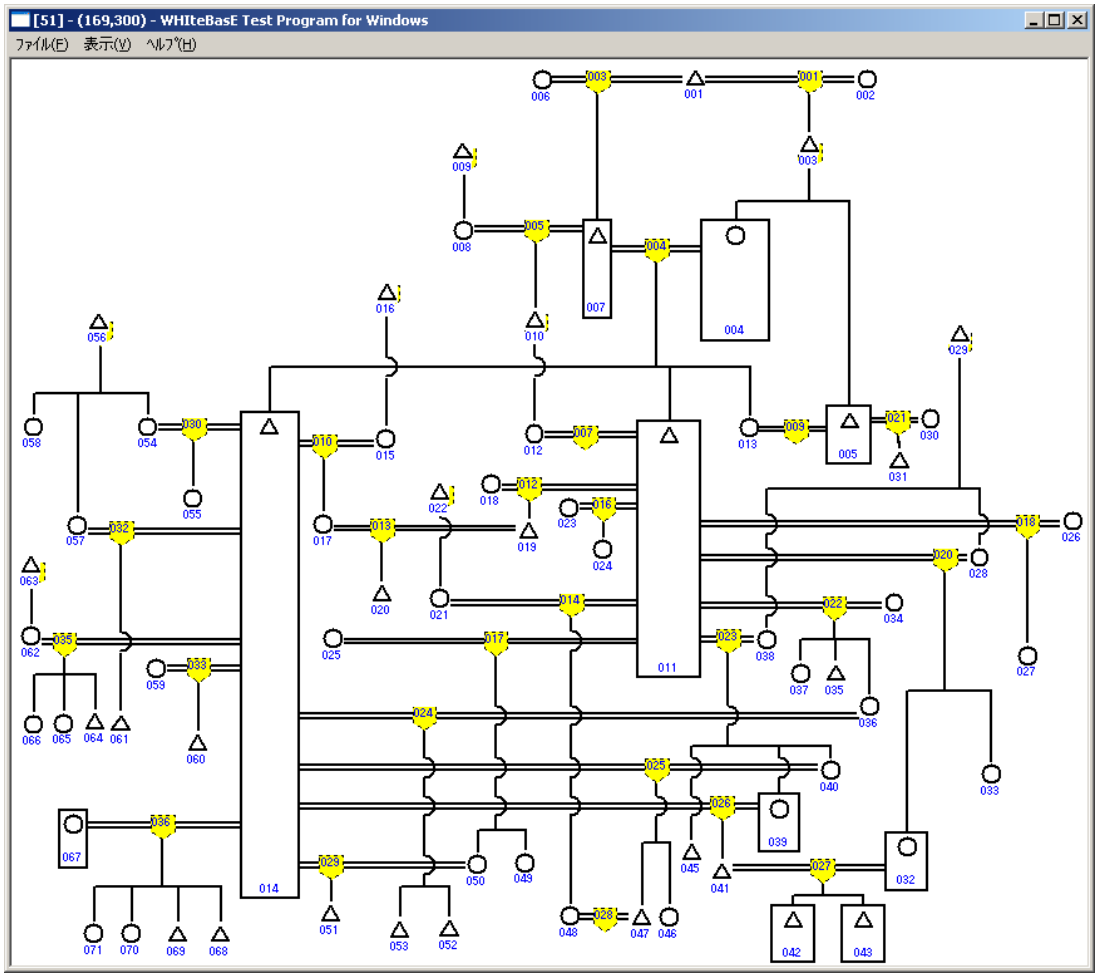


Figure. 27: Our new prototype software for displaying genealogy with segment intersections by using the WHIteBasE

The positions of segment intersections can be calculated by using these four search patterns with a round-robin searching of all WHIteBasEs. Naturally, this calculation is fast because this technique does not have to search for all segments.

B. Verification

We will discuss the correctness of the search algorithm.

1) The Minimum Unit of Segment Intersections

First, we will verify that this method can search the minimum units of segment intersections described in paragraph I-B. The coordinate values of the segment intersections as shown in Figs. 3(c),(d), Figs. 4(a),(b), Figs. 7(c),(d) and Figs. 8(e)–(h) can be calculated by using pattern 1. The coordinate values of the segment intersections as shown in Figs. 5(a),(b), Figs. 6(a),(b) and Figs. 7(a),(b) can be calculated by using pattern 2. The coordinate values of the segment intersections as shown in Figs. 5(e), Figs. 8(b)–(d) and Figs. 9(a),(d) can be calculated by using pattern 3. The coordinate values of the segment intersections as shown in Figs. 6(e), Figs. 7(e), Figs. 8(i),(l) and Figs. 9(b),(c) can be calculated by using pattern 4. Moreover, the coordinate values of the segment intersections as shown in Figs. 8(j),(k) can be calculated by using both pattern 1 and pattern 4. For this reason, it was shown that this algorithm is able to search for the minimum unit of segment intersections.

2) More Than Three Relations

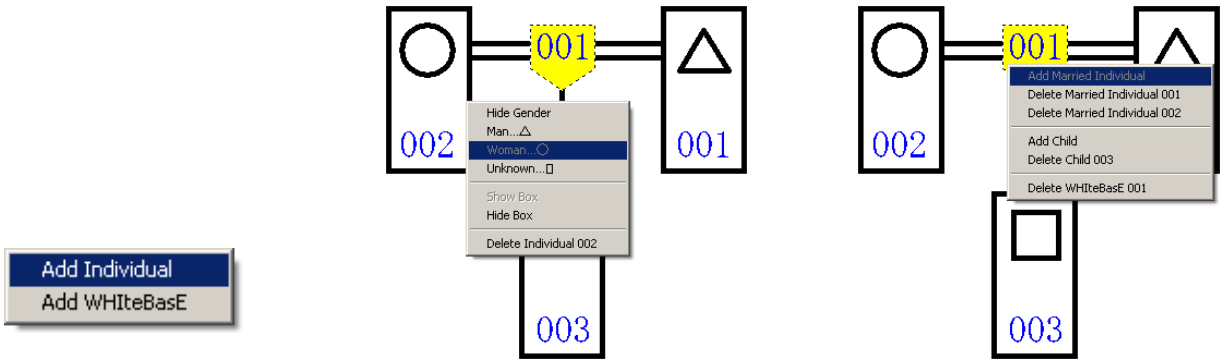
Second, we will verify the cases of more than three relations. A WHIteBasE can manage the process for occurring the new descendants. A WHIteBasE can have plural keyholes for connecting brothers and sisters, and multiple marriages can be written by using plural WHIteBasEs. So, each individual that has many relations can be managed by a WHIteBasE or more than two WHIteBasEs. In addition, all WHIteBasEs are searched by using these four patterns with necessary and sufficient conditions. Therefore, the coordinate values of segment intersections with complex relations can be found by using these four patterns with a round-robin searching of all WHIteBasEs. For this reason, it was shown that this algorithm is able to search for them if relations are more than three.

For this discussion, it was shown that this method is able to search for the positions of all segment intersections.

IV. Simulation Software

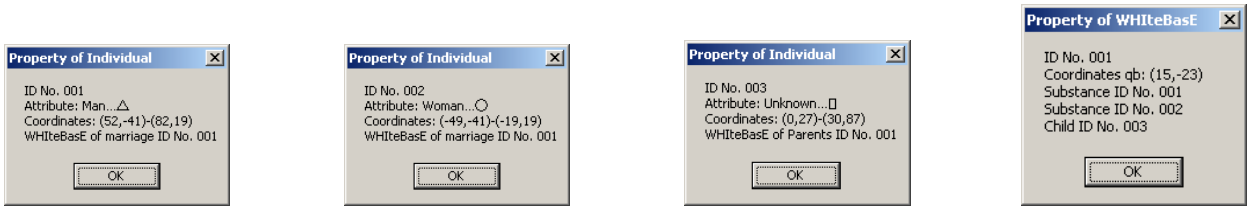
A. How to input individuals and WHIteBasEs

We developed our new prototype software for displaying genealogy with segment intersections by using WHIteBasE as shown in Fig. 27. How this genealogy was constructed is as follows: No individual and No WHIteBasE show in the display area when starting the software. The menu with



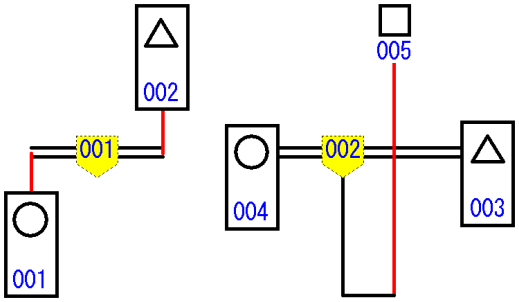
(a) Add Individual and Add WHIteBasE (b) Setting Individual (c) Setting WHIteBasE

Figure. 28: Menu by clicking the right mouse button



(a) Individual 001 (b) Individual 002 (c) Individual 003 (d) WHIteBasE

Figure. 29: Dialogs of properties by double-clicking the left mouse button



(a) Marriage Segment (b) Branch Segment

Figure. 30: The wrong arrangements are displayed by using red segments

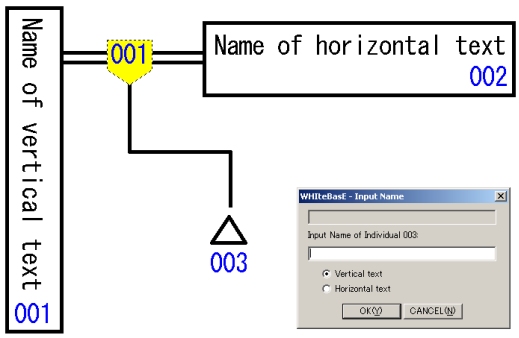


Figure. 31: The dialog for inputting name with vertical or horizontal text

"Add Individual" and "Add WHIteBasE", by clicking the right mouse button as shown in Fig. 28(a), can be used if the users want to input new data.

B. Changing attributes and connecting data

An Individual is shown by the rectangle and a WHIteBasE is shown by the pentagon with the ID respectively. The mark of the pentagon is used for displaying the management area of an event. Using the menu of Setting Individual as shown in Fig. 28(b) can change the attributes of individual; Hide Gender, Man$\cdots\triangle$, Woman$\cdots\bigcirc$ and Unknown$\cdots\square$. Moreover, it can toggle between showing and hiding the individual's box and can delete it. Using the menu of Setting WHIteBasE as shown in Fig. 28(c) can connect a WHIteBasE with a married couple and their children by drawing segments and can also delete these connections.

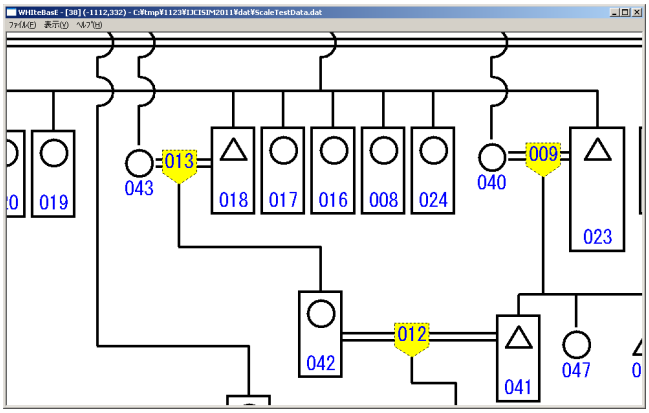
If seeing the dialogs of properties by double-clicking the left mouse button on their rectangles or pentagons, it can be verified that a WHIteBasE and individuals can be connected. If seeing the properties of individuals No. 1–3, as shown in Figs. 29(a)–(c), and seeing the attribute of a WHIteBasE, as shown in Fig. 29(d), it can be understand their connections. Of course, their connections can be understood by watching the connections of their segments.

C. Other mouse operations

The individuals and the WHIteBasEs can be put on anywhere according to the users' requirements by using mouse operations. The segment intersections can automatically be displayed on the cross points between the vertical segments and the horizontal segments by using half arcs.

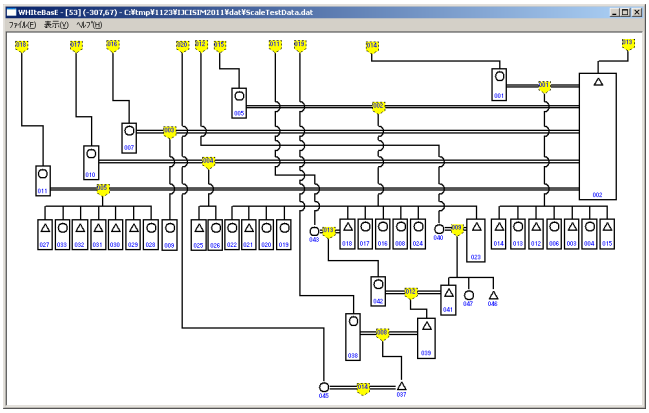
Permitting the free position, the users might put them on wrong arrangements. Therefore, the wrong arrangements can be displayed by using red segments in this system as shown in Figs. 30(a)(b). The users should change these arrangements until the red segments are lost, however, it becomes possible to arrange correctly and freely if there is no red segment.

The names of Individuals are written on the dialog for inputting name as shown in Fig. 31. This dialog has two radio buttons for selecting the vertical text or the horizontal text. If selecting the vertical text, it is shown like ID:001. If selecting



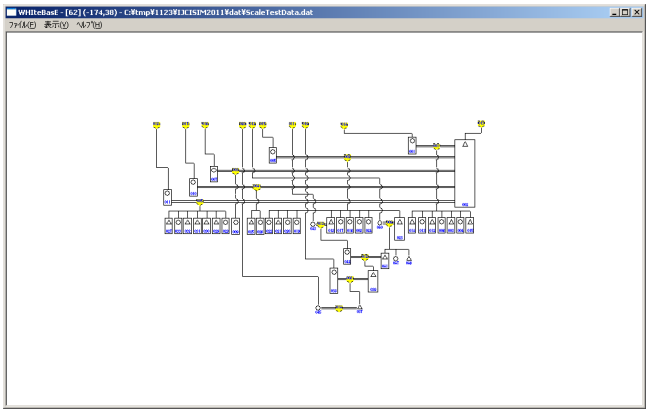
(a) Expansion scale

↑ *Seamless operation*



(b) Intermediate scale that all items can be fit to the display area

↓ *Seamless operation*



(c) Reduction scale

Figure. 32: Captured images of the changing scale

the horizontal text, it is shown like ID:002. If no input name, the attributes of individual is used for displaying the individual. The size of the individual's box can be changed by mouse drag operation. In this case, ID:003 has no name and the name is setting by the dialog.

D. Seamless operation

The size of the genealogy display area is not fixed. This mean that the users can use the infinite area for writing the genealogy to the memory limitation. That is, the outside of the client area of this window can be used. In addition, the movement command by a mouse drag control can be used for moving the display area to omni-direction, and the expansion/reduction command by spinning a mouse wheel can be used for changing the view scale. Therefore, it can be input new data easily even if the client area is fulled a lot of individuals and WHIteBasEs as shown in Figs. 32(a)–(c). Moreover, this operations are seamless like a map system displayed on a web browser.

Table 1: Comparison of the data structures for data volume of cross references

(a) Existing method

ID	F	M	S_1	C_1	C_2
1	—	—	2	3	4
2	—	—	1	3	4
3	1	2	—	—	—
4	1	2	—	—	—

F...Father, M...Mother
S...Spouse, C...Child

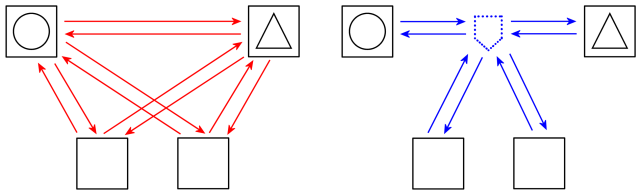
(b) New method

Individual Table

ID	A	M_1
I_1	—	W_1
I_2	—	W_1
I_3	W_1	—
I_4	W_1	—

WHIteBasE Table

ID	S_L	S_R	D_1	D_2
W_1	I_1	I_2	I_3	I_4



(a) Existing method (b) New method

Figure. 33: Comparison of the links

V. Discussion

What is the advantages of WHIteBasE? The first answer is that each event including a marriage of a couple and their children birth can be integrated in a WHIteBasE. So, the problem described in paragraph I-C can be solved easily.

The second is that the memory space of links for referring other nodes by our new method is smaller than existing method. For achieving the cross references of 4 individuals including a married couple and their two children as shown in Fig. 22(a), the software must generally hold Table 1(a) on the memory space if using existing method. That is, 10 links must be used as shown in Fig. 33(a) in this case.

On the other hand, using WHIteBasE, it must hold only 8 links as shown in Fig. 33(b). The data has two tables as shown in Table 1(b). There is no reference from an individual to others, and there are only the references between the individuals and the WHIteBasE. If the couple has only a child, the number of these links is the same, however, if they have two children, new method has less two links than existing method, if they have three children, new method is less four links. That is, if they have many children, new method is less two links per each child.

Note that this difference comes from only a family. If displaying many families, the difference becomes larger. As the result, it can be expected that the algorithm becomes simpler and faster. Moreover, input sequence becomes easier because the users can intuitively use the WHIteBasE for setting each family information.

VI. Conclusion

In this research, we proposed a new data management method for handling relations on genealogy display software easily. The volume of database became smaller, the complex relations like multiple marriages can be set easily, and the positions of segment intersections can be searched easily by using the hidden node "WHIteBasE". Our new prototype software was able to display the genealogy with segment intersections automatically, and the users could quickly input a lot of individuals' data with the relations easier than using the normal drawing tools or existing genealogy software. Therefore, displaying genealogy like a traditional handwriting style could be achieved on computers.

We will improve our genealogy display software and many solutions will be discussed in the future. For example, the large volume data will be treated, and the method for converting other data format into the WHIteBasE method will be considered.

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