Analysis of Influencing Factors of Psychological Health Status of Left-behind Children Relying on Multi-layer Linear Structural Equation Model

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Abstract
In order to analyze the psychological health status of left-behind children, it is necessary to be able to quickly generate a set of large-scale measurement data of psychological health status of left-behind children as input data for testing. This paper presents a method of analysis of influencing factors of psychological health status of left-behind children relying on multi-layer linear structural equation model. The method can construct a multi-layer linear structural equation model according to the definition of psychological element measurement and the constraints of user input, and accurately generate the measurement output results of psychological health status of left-behind children. The experimental results also show that this method has better generation efficiency than other methods, and thus is more suitable for the test on psychological health status of left-behind children.

Key words: Left-behind Children, Psychological Health Status, Measurement Analysis, Multi-layer Linear Structural Equation Model.

1. Introduction
The psychological engineering driven by the psychological health status of left-behind children is a measurement method of psychological health status of left-behind children with children measurement as the core. The children measurement and group analysis are the core components [1]. The measurement of psychological health status of left-behind children is an abstract description of the system. Group analysis is a special program of transforming one kind of children measurement into another kind of children measurement, which drives the entire measurement process and automates the measurement [2, 3]. Most of the existing work focuses on the transformation language for the measurement of psychological health status of left-behind children [4, 5, 6]. When applying group analysis techniques to psychological counseling,
scalability becomes one of the key factors that influence its success or failure [7, 8, 9]. In the case that the system being measured (or maintained) is more complicated, the transformed measurement of psychological health status of the left-behind children may be larger [10,11]. This measurement (or maintenance) process may fail if the transformation procedure does not quickly process the “measurement of psychological health status of left-behind children” [12, 13]. In addition, in the era of big data, the ability to efficiently process the “measurement of psychological health status of left-behind children” has become more and more important [14].

This paper proposes a method of analysis of influencing factors of psychological health status of left-behind children relying on multi-layer linear structural equation model. The method can measure the psychological health status of left-behind children in a reasonable time. In order to generate a correct measurement of psychological health status of left-behind children, the method considers all grammatical constraints and analysis of some influential factors defined in psychological element measurements in order to have better configurability. Finally, a set of experiments proves that the method can correctly and efficiently generate large-scale measurement data of psychological health status of left-behind children.

2. Constraints on the Measurement of Psychological Health Status of Left-Behind Children

The analysis of measurement of psychological health status of left-behind children in this paper is a process of generating the measurement of psychological health status of left-behind children based on grammatical constraints (i.e. psychological element measurement) and user options (configuration parameters). Both grammatical constraints and user options can be thought of as generating constraints. However, unlike the solver-based approach, this method does not directly solve these constraints, but uses these constraints to guide the process for measurement of psychological health status of left-behind children.

2.1. Psychological Element Measurement of Left-behind Children

Without loss of generality, the psychological element measurement $M$ can be formally defined as:

$$M = \{(T,H,A,R,assoc,mult,\prec)\}$$

$T$ is a set of classes. Among them, each element represents a type. $H$ is a set of abstract classes, and $H \subseteq T$.

$A$ is a set of attributes. Among them, each attribute $a$ belonging to $A$ can be defined as a tag function $a : t_e \rightarrow d$, where $a$ is the identifier of the attribute, $t_e \in T$ indicates the type that owns the attribute, and $d$ represents a basic data type.

$R$ is a set of references. Among them, each reference represents an association between two types of elements. $C$ represents an aggregated reference, and $C \subseteq R$.

assoc is a function whose definition is $assoc : R \rightarrow T^2$. It maps each association $r \in R$ to an ordered pair $\{src,tar\}$ of a type, indicating the source and target of the reference $r$. If $assoc(r) = \{src,tar\}$, define the symbol $r.source = src$, $r.target = tar$.

mult is also a function whose definition is $mult : R \rightarrow N_0^+ \times N_0^+$. This function is used to characterize the multiplicity of references, which refers to all non-negative integers, including $+\infty$. For each reference $r \in R$, if $(\{ts,us\},\{lt,ut\}) = mult(r)$, then $ls$ and $us$ determine lower and upper limits of the source end multiplicity, and $lt$ and $ut$ determine the lower and upper limits of the target end multiplicity.

Finally, $\prec$ represents the inheritance relationship between types, which is a partial order relationship defined on the set $T$. If $c_i \prec c_2$, it means $c_i$ is a subclass of $c_2$. In addition, this paper also defines $\cap_t = \left\{t | t \leq c\right\}$, $\cup_t = \left\{t | t \leq t\right\}$

It should be pointed out that the above definition is a simplification of the definition of the measurement of psychological health status of left-behind children from the OCL specification. It is not difficult to verify that the definition is compatible with the type diagram of the graph syntax and the Ecore (the industrial implementation of the Meta Object Facility (MOF) specification [11]).

An $M$, measurement of psychological health status of left-behind children, which meets the psychological element measurement $M$ grammatical constraint can be defined as:

$$M = \{(N,E,\text{type}_{N},\text{type}_{E})\}$$
Among them, \( N \) is the set of measurement elements of psychological health status of left-behind children; \( E \) indicates the relationship set; \( \text{type}_e \) is a function \( \text{type}_e : N \rightarrow T \), which maps the measurement elements of psychological health status of left-behind children to the corresponding types; \( \text{type}_e \) is also a function \( \text{type}_e : E \rightarrow R \) that maps the relationship to the reference.

### 2.2. Analysis of Influencing Factors on References

In addition to grammatical constraints, the generated measurement of psychological health status of left-behind children must also meet the analysis of some influencing factors. The analysis of influencing factors is diverse and involves specific areas characterized in the measurement of psychological health status of left-behind children. This paper focuses only on the analysis of four basic influencing factors that are defined in the references. The analysis of the four basic influencing factors is defined as follows:

- **Reflexivity**: This constraint determines whether the source end and target end of the \( r \)-relationship can be the same measurement element of psychological health status of left-behind children (without considering type constraints). More precisely, if \( r \) is non-reflexive, then \( \forall a \left( \langle a, a \rangle \in M \right) \). By default, all references are reflexive.
- **Order**: This constraint determines whether the reference \( r \) is a partial order. When \( r \) is ordered, then for random \( \langle e_0, e_1 \rangle \notin M \), there must not have \( e_1, e_2, \ldots, e_{n-1} \) which makes \( \bigwedge_{i=0}^{n-1} \langle e_{i+1}, e_i \rangle \in M \). By default, references are unordered.
- **Necessity**: This constraint determines whether an element must participate in an \( r \)-relationship. It has two specific types: source end necessity and target end necessity. If \( r \) is necessary for the target end, then \( \forall a \left( \sum_{a \in G} r(a) > 0 \right) \); if \( r \) is necessary for the source end, then \( \forall b \left( \sum_{b \in G} r^{-1}(b) > 0 \right) \). By default, references are not necessary for the source end, nor necessary for the target end.
- **Uniqueness**: This constraint determines whether an element can participate in multiple \( r \)-relationships. It also has two specific types: source end uniqueness and target end uniqueness. If \( r \) is unique to the target end, then \( \forall a \left( \sum_{a \in G} r^{-1}(a) \leq 1 \right) \); if \( r \) is unique to the source end, then \( \forall b \left( \sum_{b \in G} r^{-1}(b) \leq 1 \right) \). By default, references are not unique for the source end, nor unique for the target end.

The above four constraints can be extended to the reference set \( G \):

- **Reflexivity**: If \( G \) is reflexive (or non-reflexive), each of these references is reflexive (or non-reflexive).
- **Order**: If \( G \) is ordered, then for random \( \langle e_0, e_1 \rangle \notin M \), there must not have \( e_1, e_2, \ldots, e_{n-1} \) which makes \( \bigwedge_{i=0}^{n-1} \langle e_{i+1}, e_i \rangle \in M \). For any two elements \( e_0, e_n \), \( e_0 < G e_n \Leftrightarrow e_1, e_2, \ldots, e_{n-1} \left( \bigwedge_{i=0}^{n-1} \langle e_{i+1}, e_i \rangle \in M \right) \).
- **Necessity**: If \( G \) is necessary for the target end, \( \forall a \left( \sum_{a \in G} r(a) > 0 \right) \); if \( G \) is necessary for the source end, \( \forall b \left( \sum_{b \in G} r^{-1}(b) > 0 \right) \).
- **Uniqueness**: If \( G \) is unique for the target end, \( \forall a \left( \sum_{a \in G} r(a) \leq 1 \right) \); if \( G \) is unique for the source end, \( \forall b \left( \sum_{b \in G} r^{-1}(b) \leq 1 \right) \).

For example, references that represent inheritance must be non-reflexive and ordered; all sets composed of aggregated references are non-reflexive, ordered, and source end unique; in general, sets of aggregated references must also be source end necessary. This is because each element (except for the root element) must have a container.
3. Analysis Process for Influencing Factors of Psychological Health Status of Left-Behind Children

The method of this paper can be expressed as the flow shown in Fig. 1, which consists of four main steps.

The first phase is the generation of configuration parameters. In this process, a configured measurement of psychological health status of left-behind children needs to be established, including analysis of influencing factors and user-defined constraints. User-defined constraints include scope constraints and additional constraints.

The second phase is the generation of elements and attributes. Based on grammar and scope constraints, the method can create a measurement element of psychological health status of left-behind children, and set the attribute value of such element.

The third phase is the generation of all relationships. It consists of three sub-steps: 1) instantiating aggregated references (the sets of these references are ordered, non-reflexive, source end necessary and source end unique); 2) instantiating the references of configured measurement constraints of the psychological health status of left-behind children according to the analysis of influencing factors and scope constraints defined by the configured measurement of psychological health status of left-behind children; 3) instantiating common types of references. Although the relationship generation process is broken down into three sub-steps, they all use the same algorithm implementation to control different types of relationship generation by inputting different parameters.

4. Experiment and Result Analysis

This section first uses an example to show how to use the method of this paper to generate the measurement of psychological health status of left-behind children and test the performance of group analysis. Then, it uses an experiment to evaluate the multi-layer linear structural equation model of the proposed method, and uses two experiments to test the efficiency of the method.

To test the efficiency of the method herein, two experiments are performed. The first experiment compares the performance efficiency of the EMFtoCSP, Alloy, and the method of this paper. EMFtoCSP and Alloy are currently the best solvers for the measurement constraint of the psychological health status of left-behind children. At present much research work is generated on basis of their implementation of test input. The second experiment tests the efficiency of the method for generating large measurement of psychological health status of left-behind children.

4.1. Multi-layer Linear Structural Equation Model

The method in this paper is a method of multi-layer linear structural equation model. Under the same configuration, it can generate a set of diverse measurement of psychological health status of left-behind children, which can be used to calculate the average execution time of the transformation program. In order to evaluate the results for measurement of the psychological health status of left-behind children in this method, the 50 measurements of psychological health status of left-behind children are used to calculate the similarity between the measurements of psychological health status of left-behind children. The five measurements of psychological health status of left-behind children in each group are compared in pairs, and the average similarity for the measurement of the psychological health status measurement of each group of left-behind children is obtained. The similarity is calculated as follows:

\[
\text{Similarity} = \frac{\text{The matching element number}}{\text{The total element number}}
\]  

(3)

In this paper, we use the tool EMF Compare for measurement and comparison of the psychological health status of left-behind children to calculate the matching elements in the measurement of psychological health status of two left-behind children. In order to avoid any subjective bias, this paper uses the default configuration to measure and compare the psychological health status of left-behind children, and finally counts the number of matched elements and calculates the similarity. The average similarity for the
measurements of the psychological health status of each group of left-behind children is shown in Table 1.

Table 1. Similarity for the Measurements of Psychological Health Status of Left-behind Children

<table>
<thead>
<tr>
<th>Model size (#elements)</th>
<th>500</th>
<th>1000</th>
<th>1500</th>
<th>2000</th>
<th>2500</th>
<th>3000</th>
<th>3500</th>
<th>4000</th>
<th>4500</th>
<th>5000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Similarity</td>
<td>18.20%</td>
<td>19.93%</td>
<td>21.71%</td>
<td>22.77%</td>
<td>23.13%</td>
<td>23.80%</td>
<td>24.17%</td>
<td>24.54%</td>
<td>25.34%</td>
<td>25.55%</td>
</tr>
</tbody>
</table>

As can be seen from Table 1, for the MySQL psychological element measurement, the average similarity for the measurements of psychological health status of each group of left-behind children generated by this method can be controlled below 26%. That is, calculated according to EMF Compare, the measurements of psychological health status of any two left-behind children in the same group have up to 26% similar elements.

4.2. Scalability Experiment

In the experiment, the method of this paper is used to respectively generate the measurement of psychological health status of a group of left-behind children for the five psychological element measurements (excluding other constraints). For each psychological element measurement, five measurements of psychological health status of left-behind children are generated, with file sizes ranging from 1MB to 5MB. For each measurement of psychological health status of left-behind children, it is generated 5 times in order to obtain the average execution time (unit: second). The five psychological element measurements are JavaSource, extlibrary, BibTex, PetriNet, and TextualPathExp. For each measurement of psychological health status of left-behind children, in order to control the size of the measurement of psychological health status of left-behind children, the number of elements and relationships is fixed. For the corresponding five measurements of psychological health status of left-behind children under each psychological element measurement, the change ratio of element range constraint and relationship range constraint is consistent. The results of Experiment 3 are shown in Table 2.

Table 2. Results of Experiment 2

<table>
<thead>
<tr>
<th>Size</th>
<th>1MB</th>
<th>2MB</th>
<th>3MB</th>
<th>4MB</th>
<th>5MB</th>
</tr>
</thead>
<tbody>
<tr>
<td>JavaSource</td>
<td>3.94</td>
<td>13.84</td>
<td>34.49</td>
<td>63.68</td>
<td>98.05</td>
</tr>
<tr>
<td>extlibrary</td>
<td>1.94</td>
<td>7.26</td>
<td>16.36</td>
<td>29.12</td>
<td>39.86</td>
</tr>
<tr>
<td>BibTex</td>
<td>5.74</td>
<td>27.50</td>
<td>74.42</td>
<td>141.48</td>
<td>214.44</td>
</tr>
<tr>
<td>PetriNet</td>
<td>6.56</td>
<td>18.28</td>
<td>41.63</td>
<td>75.31</td>
<td>119.4</td>
</tr>
<tr>
<td>TextualPathExp</td>
<td>71.86</td>
<td>320</td>
<td>812.09</td>
<td>1776.68</td>
<td>2800.35</td>
</tr>
</tbody>
</table>

For JavaSource measurements of psychological health status of left-behind children, the time spent is between 3.94 seconds and 98.05 seconds. For the extlibrary measurements of psychological health status of left-behind children, the time spent is between 1.94 seconds and 39.86 seconds. For BibTex measurements of psychological health status of left-behind children, the time spent is between 5.74 seconds and 214.44 seconds. For PetriNet measurements of psychological health status of left-behind children, the time spent is between 6.56 seconds and 119.4 seconds. For TextualPathExp measurements of psychological health status of left-behind children, the time spent is between 71.56 seconds and 2803.35 seconds.

The performance curve of Experiment 2 is shown in Fig. 2. The function of each curve fit is also listed in the figure. For the JavaSource measurements of psychological health status of left-behind children, the performance curve obeys the function $y=5.789x^{2.2792}$; for the extlibrary measurements of psychological health status of left-behind children, the performance curve obeys the function $y=3.7502x^{2.0197}$; for the BibTex measurements of psychological health status of left-behind children, the performance curve obeys the function $y=1.9556x^{1.9096}$; for PetriNet measurements of psychological health status of left-behind children, the performance curve obeys the function $y=5.9807x^{1.8124}$; for TextualPathExp measurements of psychological health status of left-behind children, the performance curve obeys the function $y=68.936x^{2.297}$. 

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From this experiment, the following three conclusions can be obtained.

1) When the size of the psychological health status of left-behind children increases linearly, the time spent is subject to the power function $y = k \times x^p$.

2) The index $p$ varies from 1.8124 to 2.297 with an average approximation of 2.06. For different psychological element measurements, the index does not change much.

3) For different psychological element measurements, the coefficient $k$ changes drastically, which means that the coefficient $k$ is greatly affected by the complexity of the psychological element measurements.

5. Conclusions

This paper proposes an analysis algorithm for measurement of psychological health status of left-behind children relying on multi-layer linear structural equation model. It can generate measurement of psychological health status of left-behind children in compliance with grammar, semantics and scope constraints in a reasonable time. Two experiments are carried out to verify the efficiency of the method. In addition, based on the method of this paper, we will also study how to analyze the influencing factors of psychological health status of left-behind children relying on multi-layer linear structural equation model so to support complex OCL constraints. Compared with other methods, this method has better generation efficiency and is more suitable for the test on psychological health status of left-behind children.

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References


