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# Problem Solving Techniques with Extensive Computational Network and Applying in an Educational Software

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***Abstract*—**Knowledge bases are basic components of expert systems or intelligent computational programs. Knowledge bases provide knowledge, events that serve deduction activity, computation and control. Therefore, researching and developing of models for knowledge representation play an important role in computer science, especially in Artificial Intelligence Science and intelligent educational software. In this paper, the extensive deduction computational model is proposed to design knowledge bases whose attributes are able to be real values or functional values. The system can also solve problems based on knowledge bases. Moreover, the models and algorithms are applied to produce the educational software for solving alternating current problems or solving set of equations automatically.

***Keywords*—**Educational software, artificial intelligence, knowledge base systems, knowledge representation.

## I. INTRODUCTION

KNOWLEDGE has an important role in the design of expert systems. Building expert systems require designing knowledge bases and inference engine. The inference engine will find solutions of problems based on the knowledge base [1]. To research and develop knowledge deduction methods along with deduction mechanism based on knowledge base have a big significance in theory as well as computational application science in general or artificial intelligence science in particular, especially some mathematic problems based on knowledge base [2].

Nowadays, there are many knowledge representation model and some deduction methods have been researched and applied along with design assistance tools and installing program. However, these models have the same disadvantage such as: they represent a few aspects in domains of knowledge while practical knowledge is much diversified about category and property. In the Computational Object Knowledge Base model [3], which is called COKB model, and the Computational Networks were proposed. COKB model were used to design systems for solving problems in plane geometry and analytic geometry. However, those models are not suitable for designing a system to solve set of equations with many variables in Mathematics, Physics, Chemistry because elements or variables of those models only represent simple values such as real numbers while problems in this paper have functional elements.

Therefore, we build the extensive deduction computational network model that solves set of equations.[7]

## II. EXTENSIVE COMPUTATIONAL NETWORK

### *1.1 Deduction computational network*

- Definition 1**:** A computational network is a structure consisting of two components as follows:
  (1) $M = \{x_1, x_2, \ldots, x_n\}$ is a set of variables.
  (2) $F = \{f_1, f_2, \ldots, f_n\}$ is a set of deduction rules. Each rule has the form: $f: u(f) \rightarrow v(f)$ where u(f) and v(f) are disjoint subsets of M.

With each $f \in F$, M(f) is set of related variables of f, i.e. $M(f) = u(f) \cup v(f)$. [3]

This model was used in the design of many applications in education. However, the alternating current problems in general education program have specific characteristics so that a suitable model will be proposed to design a system to solve alternating current problems.

### *1.2 The Extensive Computational Deduction Network*

From the above problems, we could define the Extensive Computational Network (M,R) as follows: [4]

(1) $M = M_v \cup M_f$ is set of attributes or components that they have value in $R^+$ or functional value.

With M including two components:
- $M_v = \{x_{v1}, x_{v2}, \ldots, x_{vk}\}$ is set of $R^+$.
- $M_f = \{x_{f1}, x_{f2}, \ldots x_{fm}\}$ is set of functions.

(2) $R = \bigcup_{i \in I} R_i = R_{vv} \cup R_{fv} \cup R_{vf} \cup R_{fvf}$ is the set of deduction rules that have form f: $u(f) \rightarrow v(f)$ and I ={vv,fv, vf, fvf}, and it shows 4 cases as follows:

- $R_{vv}$: u(f) is set of real variables $\xrightarrow{R_{vv}}$ v(f) is new variable.
- $R_{fv}$: u(f) is set of functional variables $\xrightarrow{R_{fv}}$ v(f) is new variable.

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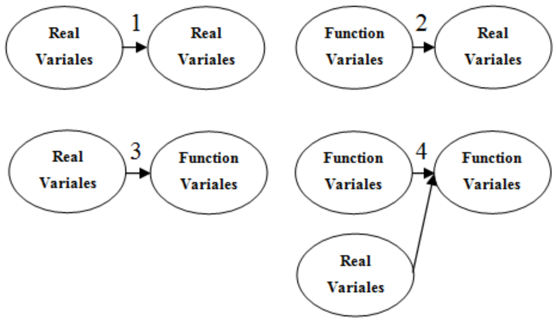


- $R_{vf}$: u(f) is set of real variables $\xrightarrow{R_{vf}}$ v(f) is new functional variable.

- $R_{fvf}$: u(f) is set of functional variables and real variables $\xrightarrow{R_{fvf}}$v(f) is new functional variable.
  u(f) and v(f) are disjoint subsets of M.

For each f ∊ R, M(f) is the set of related variables in f. Then, M(f) = u(f) ∪ v(f).

Each deduction rule in $R = \bigcup_{i\epsilon I} R_i = R_{vv} \cup R_{fv} \cup R_{vf} \cup R_{fvf}$ has the corresponding computational relation in F:

$F = \bigcup_{i\epsilon I} F_i = F_{vv} \cup F_{fv} \cup F_{vf} \cup F_{fvf}$ [4]

- $F_{vv}$: set of computational relations from set of real variables → real variable.
- $F_{fv}$: set of computational relations from set of functional variables → real variable.
- $F_{vf}$: set of computational relations from set of real variables → functional variable.
- $F_{fvf}$: set of computational relations from set of functional variables + set of real variables → functional variable.

*Example 1*: *(The Electric Circuit only has resistance)*

An electric circuit has expression i=2cos100πt(A). Let write expression of current's potential that its phase is earlier than current π/3 and effective potential is 12V.

Therefore, variables of current include components as follows:

| | |
|---|---|
| ω: angle frequency. | f: frequency. |
| T: cycle. | R: resistance. |
| ZL: inductive reactance. | ZC:capacitor reactance. |
| Z: impedance of circuit current. | I:effective current intensity. |
| U: effective potential. | $I_0$:max current intensity. |
| $U_0$: max potential. | u(t): alternating potential. |
| i(t): alternating current intensity. | $\varphi_1$ : first phase of potential. |
| $\varphi_2$ : first phase of intensity. | φ: dephasing of potential and intensity. |

With defining of the extensive deduction network model (M, R) is two sets such as:

- Set M including :

$M_v$ ={ω, f, T, R, $Z_L$, $Z_C$, Z, I, U, $I_0$, $U_0$, $\varphi_1$, $\varphi_2$, φ}
//set of real variables
$M_f$ = {u(t), i(t) }
//set of the functional variables

- Set R ={//Rules $L_1$: set of the real variables → the real variable (about 70 rules)

$R_{vv}$ ={$r_{vv1}$: f ⇒ ω; $r_{vv2}$: ω ⇒ f; $r_{vv3}$: ω ⇒ T;
$r_{vv4}$: T ⇒ ω; $r_{vv5}$: L, ω ⇒ $Z_L$;
$r_{vv6}$: $Z_L$, ω ⇒ L; $r_{vv7}$: $Z_L$, L ⇒ ω ;
$r_{vv8}$: C, ω ⇒ $Z_C$ ; $r_{vv9}$: $Z_C$, ω ⇒ C;
. . .} ;

//Rules $L_2$: set of the functional variables → the real variable

$R_{fv}$ = {$r_{fv1}$: u(t) ⇒ $U_0$ ; $r_{fv2}$: u(t) ⇒ ω;
$r_{fv3}$: u(t) ⇒ $\varphi_1$; $r_{fv4}$: i(t) ⇒ Io;
$r_{fv5}$: i(t) ⇒ ω ; $r_{fv6}$: i(t) ⇒ $\varphi_2$ };

//Rules $L_3$: set of the real variables → the functional variable

$R_{vf}$ = {$r_{vf1}$: $U_0$, ω, $\varphi_1$ ⇒ u(t); $r_{vf2}$: $I_0$, ω, $\varphi_2$ ⇒ i(t) };

//Rules $L_4$: set of the functional variables + set of the real variables → the functional variable.

$R_{fvf}$ = {$r_{fvf1}$: u(t), φ ⇒ i(t); $r_{fvf2}$: i(t), φ ⇒ u(t)}}

Correlatively each computational expressions including :

F ={//relation follow to $L_1$ (about 70 relations)

$F_{vv}$ = {$f_{vv1}$: ω = 2*π*f; $f_{vv2}$: f = ω/2*π;
$f_{vv3}$: T = 2π/ω; $f_{vv4}$: ω = 2π/T ;
$f_{vv5}$: $Z_L$= L*ω; $f_{vv6}$: L = $Z_L$/ω; $f_{vv7}$: ω = $Z_L$/L; $f_{vv8}$: $Z_C$ = 1/C*ω;
. . .} ;

//relation follow to $L_2$

$F_{fv}$ ={ $f_{fv1}$: $U_0$ = Max(u); $f_{fv2}$: ω = <first argument of (ωt+$\varphi_1$)> ;
$f_{fv3}$ : $\varphi_1$ = < second argument of (ωt+$\varphi_1$)> ;
$f_{fv4}$: $I_0$ = Max(i);
$f_{fv5}$: ω = <first argument of (ωt+$\varphi_2$)> ;
$f_{fv6}$ : $\varphi_2$ = < second argument of (ωt+$\varphi_2$)> ;

//relation follow to $L_3$

$F_{vf}$ ={$f_{vf1}$ : u(t) =$U_0$cos(ωt+$\varphi_1$); $f_{vf2}$ : i(t)=$I_0$cos(ωt+$\varphi_2$)} ;

//relation follow to $L_4$

$F_{fvf}$ ={ $f_{fvf1}$ : i(t)= $I_0$cos(ωt+$\varphi_1$-φ) ; $f_{fvf2}$ : u(t)= $U_0$cos(ωt+$\varphi_2$+φ)}} ;

## III. PROBLEMS AND SOLVING

### *1. Problems*

Given an extensive computational network **(M, R).** It is suppossed that there is A ⊆ M that it is determined; B ⊆ M is set of variables that are not determined yet. We would like to determine the variables or elements in B from the variables or elements in A.

- *Problem 1*: Can B be determined from A by using relations in R?
- *Problem 2:* If B can be determined from A, find a computational process (or a solution)?

The problem to find B from A in the extensive computational network **(M, R)** is written as $A \to B$. A is called the hypothesis, B is called the goal.

2. Solving Methods

Finding a solution of the problem is finding a sequence of deduction relations or solving set of equations such that applying of the relations from A will obtain B. Then we have a computational process or deduction process to solve the problem.

- *Definition 3*: Let **(M, R)** be an extensive computational network, A be a subset of M. A deduction rule or computational process $u \to v$ is called applying on A if $u \subset A$. A deduction relation or computational process is called applying on A if it is defined as a deduction rule applying on A. A list of deduction relations $D = [r_1, r_2, \ldots, r_k]$ is called to be applied on A if we can apply deduction or computational relations $r_1, r_2, \ldots, r_k$ from the hypothesis A.

In the definition, Put $A_0 = A$, $A_1 = A_0 \cup M(r_1)$, …, $A_k = A_{k-1} \cup M(r_k)$ and $A_k =$ **D(A)**. We can say that D(A) is obtained from A by applying D.

- ***Algorithms (3.1:)Find D(A)***:

*Input*: Giving a computational deduction network (M, R), $A \subseteq M$, and a deduction relation sequency or expression $D = [r_1, r_2, \ldots, r_k]$.

*Output*: D(A)

1. A’ ← A;
2. **for** i=1 to k **do if** <$r_i$ applying on A’> **then** A’ ← A’ ∪ M($r_i$);
3. D(A) ← A’

- ***Definition 4***: The list $D = [r_1, r_2, \ldots, r_k] \subseteq R$ is called a solution of problem $A \to B$ if we can apply computational relations $r_i$ (i=1, …, k) starting from A and will obtain variables in B. In other words, D is a solution if $D(A) \supset B$. Problem $A \to B$ is called solvable if it has a solution.

*3. Finding a solution*

*3.1. Closures*

- ***Definition 5***: Let **(M, R)** be an extensive computational network, and $A \subseteq M$. It is easy to verify that there is only the largest set $B \subseteq M$ so that $A \to B$ is solvable; B is called the closure of A on (M, R). The closure of A is denoted by $\overline{A}$.

The closure of A can be found by the following algorithms.

***Algorithms 3.2***: Find closure to $A \subseteq M$:

Input: A computational deduction network (M, R), $A \subseteq M$.

Output: $\overline{A}$

1. B ← A;
2. **Repeat** B1 ← B;

2.1 **for** $r \in R_{vv}$ **do**
  **if** <r can apply on B1> **then begin** B ← B ∪ M(r); $R_{vv} \leftarrow R_{vv} \setminus \{r\}$; **end**;

2.2 **for** $r \in R_{fv}$ **do**
  **if** <r can apply on B1> **then begin** B ← B ∪ M(r); $R_{fv} \leftarrow R_{fv} \setminus \{r\}$; **end**;

2.3 **for** $r \in R_{vf}$ **do**
  **if** <r can apply on B1> **then begin** B ← B ∪ M(r); $R_{vf} \leftarrow R_{vf} \setminus \{r\}$; **end**;

2.4 **for** $r \in R_{fvf}$ **do**
  **if** <r can apply on B1> **then begin** B ← B ∪ M(r); $R_{fvf} \leftarrow R_{fvf} \setminus \{r\}$; **end**;

Until B = B1;

3. $\overline{A}$ ← B.

*3.2. Finding a solution of problem*

The following algorithm gives a way to find a solution of problem $A \to B$ on (M, R).

- ***Algorithms 3.3***: Find a solution of problem $A \to B$

1. Solution ← empty; Goal ← B ;
2. **if** $B \subseteq A$ **then begin** Solution_found ← true; **goto** 4 ; **end ; else** Solution_found ← false ;
3. **Repeat**

Aold ← A ;
***<Search Function find r ∈ R with Heuristic’s law> ;***
**while not** Solution_found **and** (found r) **do begin**
  **if** (if we apply r and found new variable) **then begin**
   A ← A ∪ M(r); Solution ← Solution ∪ {r}; **end**;
  **if** $B \subseteq A$ **then** solution_found ← true;
  ***<Search Function find r ∈ R with Heuristic’s law>;***
**end** {while}
**Until** Solution_found **or** (A = Aold);

4. **if** not Solution_found **then <Call Function solving set of equations**>;
5. **if <definding a new variable in Function Solving set of equations> then Goto 2;**
  **else Goto 6;**
6. **end.**

***Note*** : In part above, we used to Search Function to find r that it didn’t use and continuing part , algorithms will is presented with heuristic’s law to find $r \in R$.

***Search Function find r ∈ R with Heuristic’s law*** [4]

1.**begin** Search ← <empty>; Temp ← A ;
2.**if** <Temp has functional variables> **then goto** 8
3.**if** <Goal is real variable> **then goto** 7
4.**if** <Goal is real variable> **and** <Temp has functional variables> **then begin**
  **for** $r \in R_{vv}$ **do**
   **if <if** r apply on Temp> **then begin** Search ← r ; **goto** 11;
  **end**; **goto** 8; **end ;**
5.**if** <Goal is functional variable> **then begin**

**if** <real variable in Goal> $\notin$ Temp **then**
<Finding real variables in Goal until these variables $\in$ Temp>
**goto** 9 ; **end** ;
6.**if** <Goal is functional variable> **and** <Temp has function variables> **or** <Temp has real variables> **then if** <real variable in Goal> $\notin$ Temp **then begin**
<presenting real variable in Goal until this variable $\in$ Temp>
**goto** 10 ; **end** ;
7.**for** r $\in R_{vv}$ **do if** <r applying on Temp> **then**
**begin** Search $\leftarrow$ r ; **goto** 11; **end**;
8.**for** r $\in R_{fv}$ **do if** <r applying on Temp> **then**
**begin** Search $\leftarrow$ r ; **goto** 11; **end**;
9.**for** r $\in R_{vf}$ **do if** <r applying on Temp> **then**
**begin** Search $\leftarrow$ r ; **goto** 11; **end** ;
10.**for** r $\in R_{fvf}$ **do if** <r applying on Temp> **then**
**begin** Search $\leftarrow$ r ; **goto** 11; **end** ;
11.**return** Search ;
12.**end function**;

**Function Solving set of equations**

1. begin
2. for i=1 to n do <Finding equations that have variables in Goal>
3. <Replace variables in step 2>
4. If <finding variable> then return
   Else <not solving for problem>
5. end

*Example 2*: (Physics part) [9]

Current of the electric circuit has expression i=2cos100$\pi$t(A). Let write expression of the current's potential that its phase is earlier than current $\pi/3$ and effective potential is 12V.

Therefore, variables of model (M, R) include components as follows:

- M = { $M_v$ ={ω, U, $I_0$, $U_0$, $\varphi_1$, $\varphi_2$, φ}; $M_f$ = {u(t), i(t) }}
- R ={$R_{vv}$ ={set of rules is similar example 1} ; $R_{fv}$ = {set of rules is similar example 1}; $R_{vf}$ = {set of rules is similar example 1}; $R_{fvf}$ = {set of rules is similar example 1}} ;

Set of rules, together with set of the computational representation is performed such as:

- F = {$F_{vv}$ = {set of relations is similar example 1}; $F_{fv}$ ={ set of relations is similar example 1} ; $F_{vf}$ ={ set of relations is similar example 1} ; $F_{fvf}$ ={ set of relations is similar example 1}} ;

Goal of problem represent U and u(t).

Following hypotheses of problem are defined such as: A = {U, φ, i(t)}, and set of variable should find B = {u(t)}.

Applying algorithms to find solving (algorithms 3.3), we have a solving of problem by representation relations such as: {$r_{fv4}$, $r_{fv5}$, $r_{fv6}$, $r_{vv20}$, $r_{fvf2}$}

Beginning from A set, they are applied in turn relations in solving to expand A set until find U and u:

{U, φ, i(t)} $\xrightarrow{r_{fv4}}$ {U, φ, i(t), $I_0$} $\xrightarrow{r_{fv5}}$ {U, φ, i(t), $I_0$,ω} $\xrightarrow{r_{fv6}}$ {U φ, i(t), $I_0$, ω} $\xrightarrow{r_{vv20}}$ {U φ, i(t), $I_0$, ω, φ2} $\xrightarrow{r_{fvf2}}$ {U φ, i(t), $I_0$, ω, φ2, u(t)}.

*Example 3*: (Chemistry part)

We dissolve 11,0g mixture of Al và Fe by solution HCl and achieved 8,9l $H_2$. To calculate % of Al and Al. With Al=27; F2=56.

Therefore, variables of model (M, R) include components as follows:

- M = { $M_v$ ={$m_{Fe,Al}$, $V_{H2}$}; $M_f$ = {}}
- R ={$R_{vv}$ ={set of equations in Chemistry} ; $R_{fv}$ ={}; $R_{vf}$ ={}; $R_{fvf}$ ={}} ;

  Set of rules, together with set of the computational representation is performed such as:
- F={$F_{vv}$={set of computational relations in Chemistry}; $F_{fv}$ ={}; $F_{vf}$ ={}; $F_{fvf}$ ={}};

  Goal of problem represent U and u(t).

Following hypotheses of problem are defined such as: A = {$m_{Fe,Al}$, $V_{H2}$}, and set of variable should find B = {$m_{Al}$% = x, $m_{Fe}$% = y}.

Appling algorithms to find solving (algorithms 3.3), we have a solving of problem by representation relations such as: {$r_{v1}$, $r_{v2}$, $r_{v3}$}.

{ $m_{HCl}$, $V_{H2}$, x, y } $\xrightarrow{r_{v1}}$ { $m_{HCl}$, $V_{H2}$, x} $\xrightarrow{r_{v2}}$ {determine x} $\xrightarrow{r_{v3}}$ $\{determine\ y\}$.

*Example 4*: (Mathematics part) [9]

Value of an horse is 12 Pholrin. One of 3 men buy horse but not money enough to buy horse. The first man say to those men that "Everyone let me ½ your money that I buy enough an horse". The second say to those men that "Everyone let me 1/3 your money that I buy enough an horse". The third say to those men that "Everyone let me 1/4 your money that I buy enough an horse". Let know money of everyone.

Therefore, variables of model (M, R) include components as follows:

- M = { $M_v$ ={equations include x, y, z }; $M_f$ = {}}
- R ={$R_{vv}$ ={set of equations in Mathematics}; $R_{fv}$ ={}; $R_{vf}$ ={}; $R_{fvf}$ ={}} ;

  Set of rules, together with set of the computational representation is performed such as:
- F={$F_{vv}$={set of computational relations in Mathematics}; $F_{fv}$ ={}; $F_{vf}$ ={}; $F_{fvf}$ ={}};

  Goal of problem represent is x, y, z.

Following hypotheses of problem are defined such as: A = {3 equations have variables x, y, z}, and set of variable should find B = {determine x, y, z}.

Appling algorithms to find solving (algorithms 3.3), we have a solving of problem by representation relations such as: {$r_{v1}$, $r_{v2}$, $r_{v3}$, $r_{v4}$, $r_{v5}$}.

{x, y, z not determine} $\xrightarrow{r_{v1}}$ { having equations contain x, y} $\xrightarrow{r_{v2}}$ {having equations contain x} $\xrightarrow{r_{v3}}$ {determine x} $\xrightarrow{r_{v4}}$ { determine y} $\xrightarrow{r_{v5}}$ {determine z}

3.3. Finding a Solution without redundant steps:

A solution found in algorithms (3.3) may have redundant steps. From the solution found, we can find a solution without redundant steps by the algorithm 3.4 below.

*Algorithms 3.4*: Find a solution without redundant steps (or a good solution).

*Input*: A solution $[r_1, r_2, .., r_m]$ of problem A→B.

*Output*: A good solution D of problem A→B.

1. D ← $[r_1, r_2, .., r_m]$;
2. **for** i=m **downto** 1 **do if** <D \ $\{r_i\}$ is solving > **then** D ← D \ $\{r_i\}$;
3. D is a good solution.

To rerurn example 1: From previous solving, we reject redundant steps by algorithms 3.4 and it will give us a good solving such as: $\{r_{vv20}, r_{fv5}, r_{fvf2}\}$

$\{U, \varphi, i(t)\} \xrightarrow{r_{vv20}} \{U, \varphi, i(t)\} \xrightarrow{r_{fv5}} \{U, \varphi, i(t), \omega\} \xrightarrow{r_{fvf2}} \{U, \varphi, i(t), \omega, u(t)\}$

## IV. APPLICATION

The extensive computational deduction networks and the algorithms were used to produce a system for solving problems of the alternating current. The program is implemented with Maple 12. User can input a problem into the program including the hypothesis and the goal, then the program searchs in the knowledge base to find rules for solving the problem. Below, we present some problems that are solved by the program. [8], [9]

*Example 5*: *(The Electric circuit only have coil of rope)*. An electric has a coil of rope with L=0,2H and potential of the alternating current is 220V – 50Hz. Let find effective intensity of coil.

- Following the computational representation network model is Variables ($M_v$, $M_f$), Facs and goal of problem such as:

$Mv:=\{T,w,f,R,L,C,ZL,ZC,Z,\varphi 1,\varphi 2,\varphi,U,Id,Uo,U,Id,Uo,URmax,Imax,Pmax,IoR,IoL,IoC,IR,IL,IC,Uo,UR,UL,UC\}$;

$Mf:=\{u,i\}$;

$M:=Mv\cup Mf$;

$Facts:=\{L,f,UL\}$;

$Goal:=\{IoL\}$;

$Bd:=\{L=2.10^{-1},f=50;UL=220\}$;

$Kq:=Bd$;

#-------Rules 1--------

$Rvv1:=[\{f\},\{w\},\text{"Rvv1"},w=2*3.14*f]$;

$Rvv2:=\left[\{w\},\{f\},\text{"Rvv2"},f=\frac{w}{2.3.14}\right]$;

$Rvv3:=\left[\{w\},\{T\},\text{"Rvv3"},T=\frac{2*3.14}{w}\right]$;

$Rvv4:=\left[\{T\},\{w\},\text{"Rvv4"},w=\frac{2*3.14}{T}\right]$;

$Rvv5:=[\{L,w\},\{ZL\},\text{"Rvv5"},ZL=L*w]$;

$Rvv6:=[\{ZL,w\},\{L\},\text{"Rvv6"},L=\frac{ZL}{w}]$;

$Rvv7:=\left[\{ZL,L\},\{w\},\text{"Rvv7"},w=\frac{ZL}{L}\right]$;

…

#------Rules 2-------

**If** nops(u) = 2 **then**

$Rfv:=[\{u\},\{Uo\},\text{"Rfv1"},Uo=op(1,u)]$;

$Rfv2:=[\{u\},\{w\},\text{"Rfv2"},w=op(1,op(1,op(1,op(2,u)))).op(2,op\left(1,op\left(1,op(2,u)\right)\right))]$;

$Rfv3:=[\{u\},\{\varphi 1,\text{"Rfv3"},\varphi 1=op2,op(1,op(2,u)))]$;

**end if** ;

**if** nops(u) = 3 **then**

$Rfv1=[\{u\},\{Uo\},\text{"Rfv1"},Uo=op(1,u).op(2,u)]$;

$Rfv2:=[\{u\},\{w\},\text{"Rfv2"},w=op(1,op(1,op(1,op(3,u)))).op(2,op(1,op(3,u)))]$;

$Rfv3:=[\{u\},\{\varphi 1\},\text{"Rfv3"},\varphi 1=op(2,op(1,op(3,u)))]$;

**end if** ;

**if** nops(i) = 2 **then**

$Rfv4=[\{i\},\{Io\},\text{"Rfv4"},Io=op(1,i)$;

$Rfv5:=[\{i\},\{w\},\text{"Rfv5""},w=op(1,op(1,op(1,op(2,i)))).op(2,op(1,op(1,op(2,i))))]$;

$Rfv6:=[\{i\},\{\varphi 2\},\text{"Rfv6"},\varphi 2=op(2,op(1,op(2,i)))]$;

**end if** ;

**if** nops(i) = 3 **then**

$Rfv4:=[\{i\},\{Io\},\text{"Rfv4"},Io=op(1,i).op(2.i)]$;

$Rfv5:=[\{i\},\{w\},\text{"Rfv5"},w=op(1,op(1,op(1,op(3,i)))).op(2,op(1,op(3,i)))]$;

$Rfv6:=[\{i\},\{\varphi 1\},\text{"Rfv6"},\varphi 1=op(2,op(1,op(3,i)))]$;

**end if** ;

#------Rules 3-----

$Rvf1:=[\{Uo,w,\varphi\},\{u\},\text{"Rvf1"},u=Uo.\cos(w.t+\varphi)]$;

$Rvf2:=[\{Io,w,\varphi\},\{i\},\text{"Rvf2"},i=Io.\cos(w.t+\varphi)]$;

#------Rules 4------

$Rfvf1:=[\{u,\varphi,Io,w\},\{i\},\text{"Rvfv1"},i=Io.\cos(w.t+\varphi)]$;

$Rvfv2:=[\{i,\varphi Uo,w\},\{u\},\text{"Rvfv2"},u=Uo.\cos(w.t+\varphi)]$;

- Result after runs Test:

STEP 1:

DEDUCE: $\{L=\frac{1}{5},UL=220,IoL=220\sqrt{2},f=50\}$

FROM: {UL} ; USING: UoL= UL* 2^(1/2)

STEP 2:

DEDUCE: $\{L = \frac{1}{5}, UL = 220, IoL = 220\sqrt{2}, f = 50, w = 314.00\}$
FROM: {f} ; USING: w = 6.28*f
STEP 3:
DEDUCE: $\{L = \frac{1}{5}, UL = 220, IoL = 220\sqrt{2}, f = 50, w = 314.00, T = 0.02\}$
FROM: {w} ; USING: T = 6.28/w
STEP 4:
DEDUCE: $\{L = \frac{1}{5}, UL = 220, IoL = 220\sqrt{2}, f = 50, w = 314.00, T = 0.02, C = 0.000050711\}$
FROM: {L, w} ; USING: C = 1/(L*w^2)
STEP 5:
DEDUCE: $\{L = \frac{1}{5}, UL = 220, IoL = 220\sqrt{2}, f = 50, w = 314.00, T = 0.02, C = 0.000050711, ZC = 62.80000\}$
FROM: {C, w} ; USING: ZC = 1/(C*w)
STEP 6:
DEDUCE: $\{L = \frac{1}{5}, UL = 220, IoL = 220\sqrt{2}, f = 50, w = 314.00, T = 0.02, C = 0.000050711, ZC = 62.80000, ZL = 62.80000\}$
FROM: {C, w} ; USING : ZL = L*w
STEP 7: DEDUCE: $\{L = \frac{1}{5}, UL = 220, IoL = 220\sqrt{2}, f = 50, w = 314.00, T = 0.02, C = 0.000050711, ZC = 62.80000, ZL = 62.80000, IL = 3.503184\}$
FROM: {UL, ZL} ; USING: IL = UL/ZL)
STEP 8: DEDUCE: $\{L = \frac{1}{5}, UL = 220, IoL = 220\sqrt{2}, f = 50, w = 314.00, T = 0.02, C = 0.000050711, ZC = 62.80000, ZL = 62.80000, IL = 3.503184, IoL = 3.503184 * \sqrt{2}\}$
FROM: {IL} ; USING: IoL = IL*$\sqrt{2}$

*Steps of Solution After Reduction*

STEP 1: FROM: {F} → {W}
DEDUCE: {W=314.00}
STEP 2: FROM: {C, w} → {ZC} DEDUCE: {ZC=62.80000}
STEP 3: FROM: {L, w} → {ZL} DEDUCE: {ZL=62.80000}
STEP 4: FROM: {UL, ZL} → {IL}DEDUCE: {IL=3.503184}
STEP 5: FROM: {IL} → {IoL}
DEDUCE: {IoL=3.503184*2^(1/2)}

*Example 6* : (Mathematics part)

Value of an horse is 12 Pholrin. One of 3 men buy horse but not money enough to buy horse. The first man say to those men that "Everyone let me ½ your money that I buy enough an horse". The second say to those men that "Everyone let me 1/3 your money that I buy enough an horse". The third say to those men that "Everyone let me 1/4 your money that I buy enough an horse". Let know money of everyone.[1]

- Following the computational representation network model is Variables ($M_v$, $M_f$), Facs and goal of problem such as:
- M = { $M_v$ ={equations include x, y, z }; $M_f$ = {}}
- R ={$R_{vv}$ ={set of equations in Mathematics};
  $R_{fv}$ ={}; $R_{vf}$ ={}; $R_{fvf}$ ={}} ;
  Set of rules, together with set of the computational representation is performed such as:
- F={$F_{vv}$={set of computational relations in Mathematics};
  $F_{fv}$ ={}; $F_{vf}$ ={}; $F_{fvf}$ ={}};
- Goal of problem represent is x, y, z.

Following hypotheses of problem are defined such as: A = {3 equations have variables x, y, z}, and set of variable should find B = {determine x, y, z}.

Appling algorithms to find solving (algorithms 3.3), we have a solving of problem by representation relations such as: {$r_{v1}$, $r_{v2}$, $r_{v3}$, $r_{v4}$, $r_{v5}$}.

{x, y, z not determine} $\xrightarrow{r_{v1}}$ { having equations contain x, y} $\xrightarrow{r_{v2}}$ {having equations contain x} $\xrightarrow{r_{v3}}$ {determine x} $\xrightarrow{r_{v4}}$ { determine y} $\xrightarrow{r_{v5}}$ {determine z}

- Result after runs Test:

STEP 1:
DEDUCE: $\{x + \frac{1}{2}(y + \left(12 - \frac{1}{4}(x + y)\right) = 12$ (4);
$y + \frac{1}{3}\left(x + 12 - \frac{1}{4}(x + y)\right) = 12$ (5)}
FROM: $\{x + \frac{1}{2}(y + z) = 12$ (1);
$y + \frac{1}{3}(x + z) = 12$ (2);
$z + \frac{1}{4}(x + y) = 12$ (3)}
USING: Replace equation (3) : $z = 12 - \frac{1}{4}(x + y)$ *to go in* (1) *and* (2)
STEP 2:
DEDUCE: $\{x + \frac{1}{2}\left(\frac{96}{11} - \frac{3}{11}x\right) + (12 - \frac{1}{4}\left(x + \frac{96}{11} - \frac{3}{11}x\right)) = 12\}$
FROM: $\{x + \frac{1}{2}(y + \left(12 - \frac{1}{4}(x + y)\right) = 12$ (4);
$y + \frac{1}{3}\left(x + 12 - \frac{1}{4}(x + y)\right) = 12$ (5)}
USING: Repalcing equation (5) : $y = \frac{96}{11} - \frac{3}{11}x$ *to go in* (4)
STEP 3:
DEDUCE: $\{x = \frac{60}{17}\}$
FROM: { $\{x + \frac{1}{2}\left(\frac{96}{11} - \frac{3}{11}x\right) + (12 - \frac{1}{4}\left(x + \frac{96}{11} - \frac{3}{11}x\right)) = 12\}\}$(6) ;

USING: equation (6)

STEP 4:

DEDUCE: $\{x = \frac{60}{17}; y = \frac{132}{17}\}$

FROM: $\{ y + \frac{1}{3}\left(x + 12 - \frac{1}{4}(x + y)\right) = 12\ (5)\}\}$ ;

USING: Replace x to go in (5)

STEP 5:

DEDUCE: $\{x = \frac{60}{17}; y = \frac{132}{17}; z = \frac{156}{17}\}$

FROM: $\{ z + \frac{1}{4}(x + y) = 12\ (3)\}$ ;

USING: Replace x, y to go in (3)

## V. CONCLUSION

The Extensive computational deduction network is a useful tool for knowledge representation. this model can be used to design knowledge bases in which there are functional concepts. Moreover, problems are considered more diversified in the extensive computational network model. Deduction algorithms will find out solutions of problems based on the knowledge base. Besides, the educational software in e-learning has built to solve alternating current problems in education. [10], [11]

Although knowledge about Mathematics, Physics, Chemistry in High School program cannot be represented by computational network, but it can be represented by the extensive computational network model. The Extensive computational deduction network has affirmed that it can be used to design intelligent educational softwares in many fields such as optics, mechanics, etc… Programs allow to input problems and they will find solutions of problems based on the knowledge base of the systems.

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