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A Production System of Formal Grammar for Industrial Automation Course

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Extended Abstract[+]. This research describes industrial automation courses[3] as a class of formal grammar. This defintion is based on fornal grammar as a production system, a particular notation of non-decidable grammar. This models industrial automation course as an offer of non-decidables whether service, project or training.

Keywords. service, project, training, non-decidables, industrial, automation.

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1 INTRODUCTION

This research is to note by a formal language or grammar, offers made a course centre based on industrial automation[3] setting. A production system[2] is used to generate a formal language in describing a non-decidable document by the centre.

A formal grammar[1, 2] as a production system consist of:

1. A finite Alphabet, $\sum$. The concept of alphabet used here is very general one.
2. A finite set of non-terminal symbols N .
3. A start symbol S taken out of the set of non-terminal symbol.
4. A finite set of generative rules R .

BNF as a context-free grammar[1, 2] is used to describe a class of decidables but the alternative the rules of a formal grammar is used here. The grammar defined from a production system is used to produce language sentences or document instances. A start symbol will start a production system. By applying the rules first to S, and then recursively to the outcome of the previous transformation, it is possible to generate a positive sentence of the formal language defined by the grammar[1]. Production will stop if there is no more non-terminal symbols. This example of automation grammar is a formal grammar and its formal language[1] generatives. Industrial-Automation grammar is a particular formal language and undecidable.

2 FORMAL INDUSTRIAL-AUTOMATION GRAMMAR

A total of 5 formal grammars of industrial-automation grammar[2] is needed but only 3 produced in this section. These course grammars includes *Scada, Hmi, Vfd*, Cai and Gwc.

2.1 Formal Scada Grammar

A formal Scada consists of:

- $\sum$ $is\{0,1,2,3,4,5,6,7,8,9,-,a,...z,A...Z,.,\$\}$
- N $is\{SCADA, COURSE, WMI, IFX, WCC, VCT, RSV,\}$.
- S is SCADA
- R are
    1. SCADA ---> COURSE
    2. COURSE - --> WMI
    3. COURSE ---> WMI.IFX
    4. COURSE ---> WMI.IFX.WCC

5. COURSE ---> WMI.IFX.WCC.VCT
6. COURSE ---> WMI.IFX.WCC.VCT.RSV
7. WMI ---> WONDERWARE-INTOUCH
8. IFX --->IFIX
9. WCC --->WINCC
10. VCT --->VIJEO-CITECT
11. RSV --->RSVIEW.

A Scada course is now in production system.

A student enrolls for a scada course. The following selection is made to generate course:

```
SCADA                START SYMBOL
$COURSE               after rule (1)
$WMI                       after rule (2)
$WONDERWARE-INTOUCH.   after rule (7)
```

A second student came after the first finished enrollment. The following selection is made to generate course:

```
SCADA                        Start Symbol
$COURSE                      after rule (1)
$WMI.IFX.WCC                 after rule (4)
$WONDERWARE-INTOUCH.IFX.WCC     after rule (7)
$WONDERWARE-INTOUCH.IFIX.WCC    after rule (8)
$WONDERWARE-INTOUCH.IFIX.WINCC  after rule (9).
```

The third did a selection of 4 from 5 courses and this generated the production system:

```
SCADA                           START SYMBOL
$COURSE                         after rule (1)
$WMI.IFX.WCC.VCT                 after rule (5)
$WONDERWARE-INTOUCH.IFX.WCC  after rule (7)
$WONDERWARE-INTOUCH.IFIX.WCC after rule (8)
$WONDERWARE-INTOUCH.IFX.WINCC  after rule (9)
$WONDERWARE-INTOUCH.IFIX.WINCC.VIJEO-VITECT.after rule 10
```

The fourth student preparing to enroll in 2 courses has a production system for the selection:

```
SCADA START SYMBOL
$COURSE   after rule (1)
$WMI.IFX      after rule (3)
$WONDERWARE-INTOUCH.IFX  after rule (7)
$WONDERWARE-INTOUCH.IFIX. after rule (8)
```

The fifth student did a selection of 5 courses and this generated the production system:

```
SCADA START SYMBOL
$COURSE   after rule (1)
$WMI.IFX.WCC.VCT.RSV      after rule (5)
$WONDERWARE-INTOUCH.IFX.WCC.RSV  after rule (7)
$WONDERWARE-INTOUCH.IFIX.WCC.RSV after rule (8)
$WONDERWARE-INTOUCH.IFX.WINCC.RSV  after rule (9)
$WONDERWARE-INTOUCH.IFIX.WINCC.VIJEO-VITECT.RSV after
rule (10)
$WONDERWARE-INTOUCH.IFIX.WINCC.VIJEO-VITECT.RSVIEW. after
rule (11)
```

2.2 Formal HMI Grammar

A formal Hmi consists of:

- $\sum is\{0,1,2,3,4,5,6,7,8,9,-,a,...z,A...Z,.,\$\}$
- N $is\{HMI, COURSE, PAW, TOH, DET, FAT\}$.
- S is HMI
- R are
    1. HMI ---> COURSE.DAYS
    2. COURSE - --> PAW
    3. COURSE ---> PAW.TOH
    4. COURSE ---> PAW.TOH.DET
    5. COURSE ---> PAW.TOH.DET.FAT
    6. DAYS --->5
    7. DAYS ---> 10

8. DAYS ---> 15
9. DAYS --->20
10. PAW ---> PANEL-VIEW
11. TOH --->TOUCH
12. DET --->DELTA
13. FAT ---> FACTORY-TALK.

A student choose a course and this generates the production system:

HMI	Start Symbol
$COURSE.DAYS	after rule (1)
$COURSE.5	after rule (6)
$PAW.5	after rule (2)
$PANEL-VIEW.5.	after rule (10)

A student from Kumasi chooses 3 courses from HMI production system and that gives:

HMI	Start Symbol
$COURSE.DAYS	after rule (1)
$PAW.TOH.DET.DAYS	after rule (6)
$PANEL-VIEW.TOH.DET.DAYS	after rule (10)
$PANEL-VIEW.TOUCH.DET.DAYS	after rule (11)
$PANEL-VIEW.TOUCH.DELTA.DAYS	after rule (12)
$PANEL-VIEW.TOUCH.DELATA.10.	after rule (7)

A third student select four courses and HMI production system gives:

HMI	Start Symbol
$COURSE.DAYS	after rule (1)
$PAW.TOH.DET.FAT.DAYS	after rule (6)
$PANEL-VIEW.TOH.DET.FAT.DAYS	after rule (10)
$PANEL-VIEW.TOUCH.DET.FAT.DAYS	after rule (11)
$PANEL-VIEW.TOUCH.DELTA.FAT.DAYS	after rule (12)
$PANEL-VIEW.TOUCH.DELTA.FACTORY-TALK.DAYS	after rule (13)
$PANEL-VIEW.TOUCH.DELATA.FACTORY-TALK.15.	after rule (8)

The next student after the third student who selected 4 made a selection of 2 courses and that gives a production system:

HMI	Start Symbol
$COURSE.DAYS	after rule (1)
$PAW.TOH.DAYS	after rule (6)
$PANEL-VIEW.TOH.DAYS	after rule (10)
$PANEL-VIEW.TOUCH.DAYS	after rule (11)
$PANEL-VIEW.TOUCH.10.	after rule (7)

2.3 Formal VFD Grammar

A formal Vfd consists of:

- $\sum is \{0,1,2,3,4,5,6,7,8,9,-,a,...z,A...Z,.,\$\}$
- N is $\{VFD, COURSE, POF, YAA, DEL, ABB, EME, SCH\}$.
- S is VFD
- R are
    1. VFD ---> COURSE.DAY
    2. COURSE - --> POF
    3. COURSE ---> POF.YAA
    4. COURSE ---> POF.YAA.DEL
    5. COURSE ---> POF.YAA.DEL.ABB
    6. COURSE ---> POF.YAA.DEL.ABB.EME
    7. COURSE ---> POF.YAA.DEL.ABB.EME.SCH
    8. POF ---> POWERFLEX
    9. YAA ---> YASKAWA
    10. DEL ---> DELTA
    11. EME ---> EMERSION
    12. SCH ---> SCHNEIDER
    13. DAY ---> 5

A VFD student enrolls for 3 subjects in this course and that gives a production system:

VFD	Start Symbol
$COURSE.DAY	after rule (1)
$POF.YAA.DEL.DAY	after rule (4)
$POWERFLEX.YAA.DEL.DAY	after rule (8)

$POWERFLEX.YASKAWA.DEL.DAY	after rule (9)
$POWERFLEX.YASKAWA.DELTA.DAY	after rule (10)
$POWERFLEX.YASKAWA.DELTA.5.	after rule (13)

A VFD student enrolls for 2 subjects in this course and that gives a production system:

VFD	Start Symbol
$COURSE.DAY	after rule (1)
$POF.YAA.DAY	after rule (4)
$POWERFLEX.YAA.DAY	after rule (8)
$POWERFLEX.YASKAWA.DAY	after rule (9)
$POWERFLEX.YASKAWA.5	after rule (13)

A VFD student enrolls for 4 subjects in this course and that gives a production system:

VFD	Start Symbol
$COURSE.DAY	after rule (1)
$POF.YAA.DEL.ABB.DAY	after rule (4)
$POWERFLEX.YAA.DEL.ABB.DAY	after rule (8)
$POWERFLEX.YASKAWA.DEL.ABB.DAY	after rule (9)
$POWERFLEX.YASKAWA.DELTA.ABB.DAY	after rule (10)
$POWERFLEX.YASKAWA.DELTA.ABB.5.	after rule (13)

A VFD student enrolls for 5 subjects in this course and that gives a production system:

VFD	Start Symbol
$COURSE.DAY	after rule (1)
$POF.YAA.DEL.ABB.EME.DAY	after rule (4)
$POWERFLEX.YAA.DEL.ABB.EME.DAY	after rule (8)
$POWERFLEX.YASKAWA.DEL.ABB.EME.DAY	after rule (9)
$POWERFLEX.YASKAWA.DELTA.ABB.EME.DAY	after rule (10)
$POWERFLEX.YASKAWA.DELTA.ABB.EME.5	after rule (13)
$POWERFLEX.YASKAWA.DELTA.ABB.EMERSION.5.	after rule (11)

A VFD student enrolls for 6 subjects in this course and that gives a production system:

VFD	Start Symbol
$COURSE.DAY	after rule (1)
$POF.YAA.DEL.ABB.EME.SCH.DAY	after rule (4)
$POWERFLEX.YAA.DEL.ABB.EME.SCH.DAY	after rule (8)
$POWERFLEX.YASKAWA.DEL.ABB.EME.SCH.DAY	after rule (9)
$POWERFLEX.YASKAWA.DELTA.ABB.EME.SCH.DAY	after rule (10)
$POWERFLEX.YASKAWA.DELTA.ABB.EME.SCH.DAY	after rule (13)
$POWERFLEX.YASKAWA.DELTA.ABB.EMERSION.SCH.5.	after rule (11)
$POWERFLEX.YASKAWA.DELTA.ABB.EMERSION.SCHNEIDER.5.	after rule (12)

3 CONCLUSION

This research work concludes on formal grammar and its production system. In here, 3 different industrial-automation grammar are produced and a language is made from the production sytem for each. Industrial-automation grammar considered Human Machine Interface, Variable Frequency Drive and Supervisory Control And Data Acquisition courses and their grammar.

Compliance with Ethical Standards

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Conflict of Interest:

Author, Dr. Frank Appiah declares that he has no conflict of interest .

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