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Automated Generation of EXPRESS-G Models Using NLP

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Abstract: The EXPRESS notation helps in representing a model's elements, definitions, connections and cardinalities textually and graphically. The graphical version of EXPRESS language is called EXPRESS-G. EXPRESS-G provides a standardized way of representing the structure of an information model in a more reasonable way. In the recent times, the graphical representations of the software architecture are preferred due to its ability of easy to understand. In this article, a novel idea is presented to generate EXPPRES-G models from Natural Language (NL) text such as SBVR specification. In this study, an automated system is introduced that generates an EXPRESS graphical data models from SBVR, a controlled natural language. The approach is tested on various case studies and the EXPRESS models are generated from SBVR rules. Since, model representation is helpful to develop large scale systems like, Aerospace, medical science and other industries where the representation of system working is important, there is vast application of the idea discussed in this paper. This work is helpful to the data mangers and IT managers to represent their organization structure in a simple way.

Keywords: EXPRESS models Natural Language Processing, SBVR

1. INTRODUCTION

In modern data modelling, different types of Data Modelling languages have been available. There are two types of Modeling Languages these are textual and graphical. In textual modeling language is use standard keywords associated by natural language expression and phrases or variables make computer explainable terms (Sani, *et al.,* 2011). Diagram techniques with named symbols are typically used in graphical modeling language to represent concepts and lines that join the arbitrary signs and show the connection between them and various elements represented by using graphical notations. The EXPRESS notation is an example of a textual modelling language and graphical modeling language. The EXPRESS-G (Yan, 2013) and EXPRESS (OMG, 2014) (International Standard Organization 10303-11) are international standard nonspecific purpose data modeling language.

2. BASIC CONCEPTS

a. EXPRESS (Data Modelling Language)

A standard language for modelling material extracted from software products is called EXPRESS and the exchange type of model STEP (10303) standard in ISO is formalized for EXPRESS (OMG, 2014) and the evolved standard is 10303-11. The problem domain representation into EXPRESS model is achieved through different schemas which are used for grouping elements having similar semantic and persistence. The different data types including plain types e.g. String or integer containers e.g. LIST or SET, enumerations and data types defined by users are assisted by EXPRESS language entity types is a key type in EXPRESS language to define the elements and constraints.

b. Data Modelling

Information Modeling is a system used to portray and analyze data necessities anticipated that would backing the business structures inside the degree of looking at information systems in affiliations and the technique of data showing incorporates capable data modelers working almost with business accomplices, As well as potential customers of the information structure.

c. Semantic Business Vocabulary Rules

It is an openly accessible determination from the Object Management Group expected the premise for a prescribed and documented characteristic dialect revelatory depiction of a complex substance, for example, a commercial, SBVR (OMG, 2013) is prearranged to validate difficult agreeability standards, for example, operational principles for an undertaking, security strategy, standard consistence, or administrative agreeability rules.

d. Model Transformation

A model change, in model-driven designing is an automatable method for guaranteeing that a group of models is reliable, in an exact sense which the product architect can characterize and the point of utilizing a model change is to spare exertion and lessen lapses via computerizing the building and adjustment of models where conceivable. A model change may be composed in a broadly useful programming dialect, however

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specific model change dialects are additionally accessible.

3. RELATED WORK

a. EXPRESS Data Models

An EXPRESS model on a database vault is implemented questioned upon and controlled (Goh, *et. al.,* 1996). They introduced a product advancement stage which aids creators to make EXPRESS models, to produce a proportional database composition and to control this mapping. Likewise they can make an introductory EXPRESS model utilizing EXPRESS-G. EXPRESS code is then created and further altering embraced utilizing a particular EXPRESS proofreader. They can likewise imagine the legacy chain of importance of the complete pattern. The EXPRESS pattern is changed over to an article situated database framework and got to by means of a SDAI. They portray every segment of the advancement stage furthermore inspect the conceivable improvements. The STEP (ISO 10303) standard (Wei, *et al.,* 2009) particularly plans to give a viable means by which item data can be imparted, traded in the middle of utilizations and ventures. EXPRESS is a modeling language inside the STEP particulars and it is utilized to portray item information. EXPRESS can represent the database models with possibility distribution, extended FUZZY sets and integrating such EXPRESS FUZZY data base models (Ma, 2006). The EXPRESS FUZZY models can be further mapped to object oriented FUZZY database by using formal techniques. The data access standard interface requirements are investigated for functioning the EXPRESS data models that are defined in a database. Different integrated algorithms are developed depending on the basis of object oriented FUZZY data for SDAI (STEP Data Access Interface) procedures.

The proposed EXPRESS metamodel (Omar, 2001) follows three main concepts the Resource, View and Domain. Similarly, a technique was developed that was based on ontology for interoperable meaning and logic of model knowledge (Zhao, *et al.,* 2008). Two languages namely OWL and SWRL for web semantics are used to develop information model of product. They disused EXPRESS language as traditional language they presented information model of EXPRESS oriented product using representation technique. They introduced the importance of representing techniques such as configuration from EXPRESS to other formal models (Oehmen, 2015). An automated structure for controlling EXPRESS models was described (Kahn, *et al.,* 2001) and the objective is to hold the STEP idea of the direct mapping of a data model to a usage, yet to do as such in a manner that empowers elective execution techniques to be received. In this structure, called STEPWISE, permits the client to point out controls and model changes keeping in mind the end goal to change over models from one structure into an alternate.

Zhao, and Liu (2008) developed a technique which is based on ontology for interoperable meaning and logic of model knowledge. Two languages namely OWL and SWRL for web semantics are used to develop information model of product. They disused EXPRESS language as traditional language they presented information model of EXPRESS oriented product using representation technique. They introduced the importance of representing technique is configured from EXPRESS to SWRL/OWL.

b. SBVR and Model Transformations

A few transformations have been presented to generate formal models from SBVR such as SBVR to UML (Afreen, *et al.,* 2011), SBVR to BPMN (Skersys, *et al.,* 2012), SBVR to OCL (Bajwa, *et al.,* 2014), etc. As a matter of first importance issue of SBVR parsing was had a tendency to by using typical Natural Language Processing approaches and Second issue of progress of SBVR metamodel essentials to UML class diagram metamodel segments was had a tendency to by using model change development (Afreen, *et al.,* 2011). Their exhibited methodology takes include the product prerequisites detailed in SBVR grammar, deconstructs the information determination, removes the UML fixings, for example, classes, techniques, traits, affiliations, and so forth lastly create the visual representation of the separated data. A similar transformation from SBVR to OWL2 (Reynares, *et al.,* 2014). Since, the created ontologies generally beat the negligibly adequate quality, as indicated by the considered quality appraisal system. In this method there is no measurable significant contrast between the quality scores of the ontologies grew by method for UML and SBVR strategies, in any of the surveyed quality measurements. Their outcomes confirm past exploration about the viability of UML methodologies for conceptualizing lightweight ontologies while focusing on the capability of the SBVR dialect to express unpredictable thoughts of an area of investment. Likewise highlighted the capability of SBVR to OWL 2 mappings as a cosmology improvement state. Another similar work is generation of SBVR from natural language (Ramzan, *et al.,* 2014) where an approach of model transformation is presented to generate SBVR from NL text. A transformation framework from SBVR to SPARQL was presented (Sukys, *et al.,* 2012). This transformation depends on OWL 2 ontology related with corresponding SBVR vocabulary and rules. They performed a set of transformations and metamodels required for relating ontologies, rules, SPARQL queries and real business data supported by computerised information systems.

4. USED APPROACH

a. SBVR to EXPRESS Transformation Framework

In this framework, the SBVR specifications is processed to find the SBVR elements and then describe individually to map them to EXPRESS metamodel elements that are found from the EXPRESS Metamodel by using model transformation technology and a set of transformation rules. Afterwards, both metamodel elements are compared and described them individually after extraction phase. **(Fig. 1)** shows the used framework for model transformation of SBVR rules to the EXPRESS data model and this transformation is governed by a set of transformation rules.

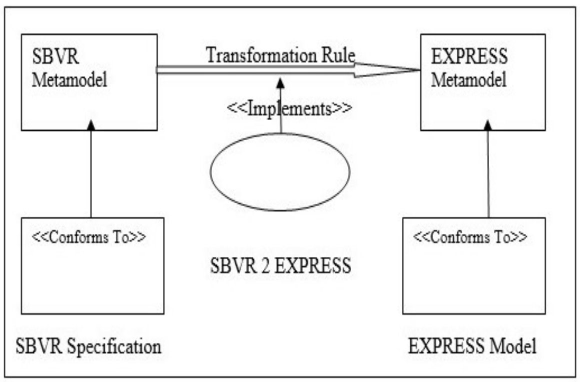

Fig 1. SBVR to EXPRESS Transformation Framework

b. Semantic Analysis of SBVR Specifications

To distinguish the SBVR vocabulary, semantic part naming is performed and Semantic part marking or topical part marking is a shared methodology utilized as a part of shallow semantic parsing, and the SBVR components, for example, thing idea, singular idea, article sort, verb ideas are distinguished from the SBVR data **(Fig. 2)**.

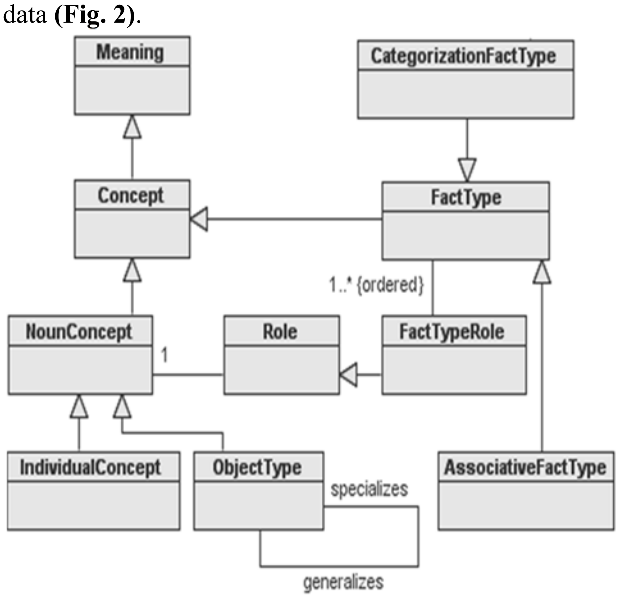

Fig 2. A subset of SBVR (meaning) Metamodel

c. Extracting SBVR Elements.

The initial phase is to extract SBVR vocabulary elements from input SBVR behavioral rules and representing them into different classes of SBVR vocabulary. The process of extracting SBVR vocabulary items is described in the following text:

i. Extracting Noun Concept

Different methods are used to describe the noun and noun phrases in English language, In old-fashioned syntax, nouns are imparted to be words that mention to individuals, things, places, or immaterial concepts and while up-to-date morphology discover this classification to be challenging because it depend on generic nouns such as objects to exactly define what a noun is, in our community thoughtful of what nouns are complies to the old-fashioned meaning but in SBVR, the mutual noun phrase (co-actors, actors, recipients, thematic things,) or nouns, are plotted as the object types e.g. employee, tools, , chair, etc.

ii. Extracting Individual Concepts

The logical mapping to singleton types of individuals and each single type of individual has exactly one element, which is the instance of the proper nouns (recipients, co actors, actors and thematic objects) and distinct concept, are plotted to the distinct ideas. In the distinct noun concept 'Bahawalpur' is a one instance and it is a specific state in the Punjab of Pakistan. The General concepts, Individual noun concepts, Verb concepts, noun concept and concept type are also defined individual concepts.

iii. Extracting Fact Types

In SBVR fact types (kinds of facts, such as "Employee works for Department") are explained obligation the subordinate and exploit verbs are characterized as verb ideas, and Association, Property, Property association, Partitive verb ideas to building a Fact kinds. Examples of fact-based representation of a database scheme, the information structure implied by the database scheme can be expressed as a set of fact types and constraints as follows, using the capitalized mix fix notational style described earlier: Types of individuals are Employee, Car, Employee Number, Employee Name and Car Registration Number.

iv. Extracting Characteristics

In SBVR, trademark which is key to comprehension an idea. An idea has an inferred trademark just on the off chance that it takes after by sensible ramifications from some blend of consolidations of attributes by ideas and/or structural standards that the trademark is constantly ascribed to every example of the idea. Furthermore clarify parallel verb idea, unitary thing idea and individual thing idea. Every example of every trademark sort is a trademark.

The augmentation of the trademark sort "shading" incorporates the attributes 'thing is blue', 'thing is red', 'thing is green' and so forth **(Fig. 3)**.

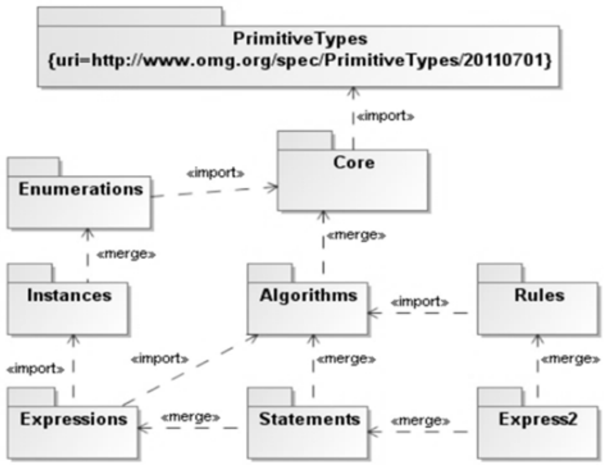

Fig 3. A subset of EXPRESS Metamodel

The Core Package contains all of the generally required modeling elements of EXPRESS, along with some basic metamodel artifacts, and it is the foundation on which all of the other packages are built. The Core Package is the minimal implementation of the EXPRESS Metamodel, and the Core package contains all of the generally required modeling elements of EXPRESS, including: (**Table 1)**

- Scopes and Naming concepts
- Schemas
- (Data) Types
- Entities, Attributes, and Relationships
- Domain Constraints

The Core package also includes the abstract classes Expression and Instance, which serve as linking points for detailed models contained in other packages.

Table 1. Easy-Going plotting among Semantic Business Vocabulary Rules and Express Metamodel Elements

Main elements of SBVR Rule Metamodel	Main elements of EXPRESS Metamodel
Individual Concept	Object
Noun Concept	Class
Verb Concept	Methods
Business Rule	Schema
Definitional Rule	Global Rules
Characteristic	Attribute
Elementary Concepts	Base Type
Constraints	Constraints
Partitive Fact Type	Generalization
Associative Fact Type	Association
Categorization Fact Type	Aggregation
Quantification	Cardinalities

d. Transformation SBVR to Named Type

Semantic Business Vocabulary Rules are transformed to the Named Type and present the rules of transformation. The all elements of the EXPRESS model is mapped with the elements of SBVR by using rules of transformation and the above section is already discussed the extraction of SBVR specifications which are used in this transformation.

In the below describe the transformation method of mapping SBVR elements with element of EXPRESS data models:

i. Transformation Verb Concepts to Methods

In this section we transform or map verb concepts (action verbs) of the SBVR are related to a noun concept are transformed and Verb concepts map to fact types, each fact type being a set of possible ground facts that can be formulated based on the verb concept and that use reference schemes to identify, for each fact, each thing that fills each role.

ii. Transformation Noun Concept to EXPRESS Class

In the Semantic Business Vocabulary Rule, entirely the Noun Concepts are transformed to EXPRESS classes in an EXPRESS Core Package model. The idea that is the importance of a thing or thing expression.

iii. Transformation Individual Concepts to Objects

In this phase transform all individual concepts and its sub elements of Semantic Business Vocabulary Rule to the objects in an EXPRESS Core model and all the general, individual, noun concepts, verb concepts and concept types are mapped to object and with its elements. *Individual Noun Concepts* logically map to singleton types of individuals. Each single type of individual has exactly one element, which is the instance of the individual noun concept.

iv. Transformation Definitional Rule to Global Rule

A Schema Element denoting a collection of Named Rules for the interaction of the Extents of one or more Entity Types and It corresponds to the RULE declaration in EXPRESS, every Global Rule is also an Algorithm Scope and may define Common Elements and Variables **(Fig. 4)**.

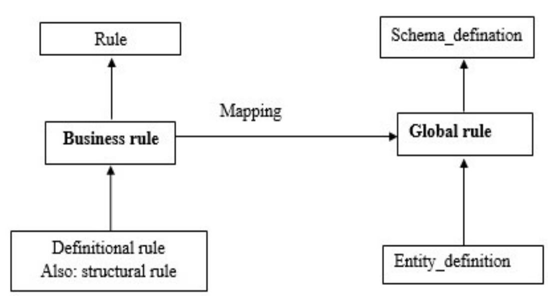

Fig 4. Mapping from SBVR Rule to EXPRESS Rule

v. Transformation Characteristics to Attribute

The concept of SBVR element characteristics is mapped with the element of EXPRESS element Attribute. The characteristic "driver is of age" by this meaning: "the age of the driver is at least the EU-Rent Minimum Driving Age." In this element dualistic verb concept, unitary noun concept and individual noun concept are also sub elements are mapped with the sub elements of Attribute like *Entity* Definition, *Inverse* attribute, *Explicit* attribute, *Derived* attribute and *Base* type **(Fig 5)**.

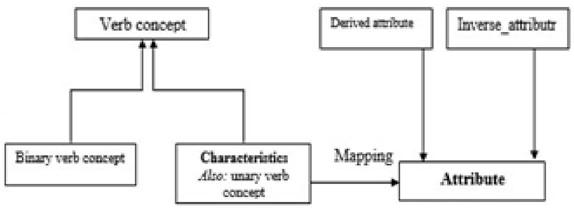

Fig 5. Mapping SBVR characteristics to EXPRESS attributes

vi. Implementation Details

Our aim is to define a transformations from natural language based SBVR to an EXPRESS behavioral model. In this paper, the focus is model to model transformation from a SBVR specification to an EXPRESS model. We make the assumptions that the input SBVR specification is consistent and complete.

The used approach is divided into two steps:

- Firstly Extracting SBVR elements.
- Define applied Business Rules transformations to the control flow of the identified elements of EXPRESS and to potentially refine them.

5. EXPERIMENTS AND RESULTS

The following case study helps us to generate the EXPRESS data model by using SBVR rules and system requirements:

"The car rental company EU-Rent has 1000 renting branches and 200,000 cars in towns all over Europe. At each branch cars, classified by car group, are available for rental. Each branch has a manager and booking clerks who arrange rentals and reservations for future rentals. Cars rented from one branch of EU-Rent may be returned to any other branch. The rental period and the car group are specified at the time of reservation. The renting branch must ensure that the car has been returned to some branch at the end of the rental period. If a car is returned to a branch other than the one that rented it, the car is assigned to the new branch. At the end of each day cars are assigned to reservations for the following day. If no car of a requested group is available, a branch manager may ask other nearby branches if they have cars they can transfer to him. EU-Rent has 400 service depots, each serving several branches. Cars may be booked for maintenance at any time provided that the service depot has capacity on the day in question. For simplicity, only one booking per car per day is allowed. A rental or service may cover several days. There are about 20,000,000 rental bookings and 800,000 service bookings per year. A customer can have several reservations but only one booking at a time. EU-Rent keeps records of about 5,000,000 customers, their rentals and bad experiences with customers. This information is used to decide whether to approve a rental. Customer records are kept until ten years after their last rental."

a. Use Generated SBVR Vocabulary

In the following table **(Table 2),** the SBVR vocabulary is extracted from the case study paragraph and it is further used to develop or generate the EXPRESS model diagram using SBVR rules.

Table 2. List of Generated SBVR vocabulary

Category	Count	Details
Noun Concept	04	car movement, receiving branch, geographical movement type
Verb Concepts	01	receiving branch
Individual Concepts	04	car group, movement-id, rental car, movement-id
Characteristics	02	directional movement type, local car movement
Quantifications	01	in-country car movement,
Constraints	02	one-way car, movement
Associative Fact Types	01	sending branch
Partitive Fact Types	01	round-trip car movement
Categorization Fact Types	01	international car movement

b. SBVR Rules

Following are SBVR rules extracted from the input case study shown above. Following are the SBVR rules represented in SBVR Semantic English notation (OMG, 2013).

SBVR Rule: It is necessary that each rental *has* exactly one requested car group.

SBVR Rule: It is necessary that each rental *includes* exactly one rental period.

SBVR Rule: It is necessary that the scheduled pick-up date/time *of* each advance rental *is after* the booking date/time *of* the rental booking that *establishes* the advance rental.

SBVR Rule: It is necessary that each rental *has* exactly one return branch.

SBVR Rule: It is obligatory that the service reading *of* a rental car *is* at most 5500 **miles**.

SBVR Rule: If the rented car *of* an open rental *is in need of service* or *is in need of repair* then it is obligatory that the rental *incurs* a car exchange during rental.

c. Generated EXPREES Diagram

Output of the SBVR to EXPRESS-G model of the example discussed previously is shown in **(Fig. 6).**

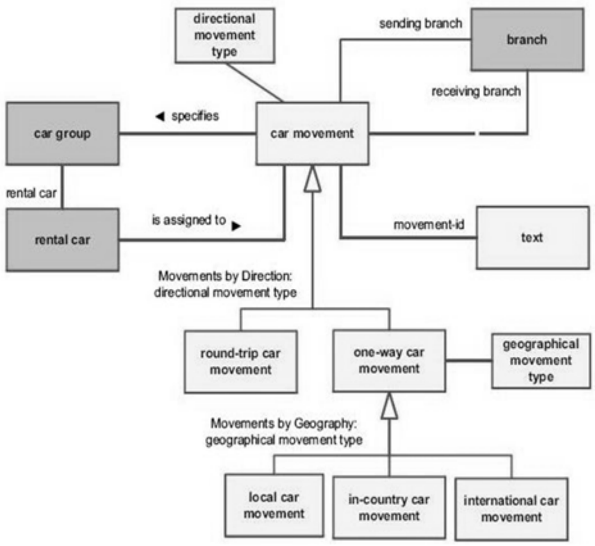

Fig 6. Generated EXPRESS diagram

d. Results

There were seven sentences in the used case study problem. The largest sentence was composed of 59 words and the smallest sentence contained 18 words. The average length of all sentences is 26. The major reason to select this case study was to test our tool with the complex examples. The correct, incorrect, and missing SBVR elements are shown in Table 3.

Table 3. Results of SBVR to EXPRESS Transformation

#	Type/Metrics	$N_{example}$	N_{True}	N_{False}	N_{error}
1	Noun Concept	09	9	0	0
2	Verb Concepts	08	7	1	0
3	Individual Concepts	09	8	0	1
4	Characteristics	04	4	0	0
5	Quantifications	06	6	0	0
6	Constraints	10	8	1	1
7	Associative Fact Types	04	4	0	0
8	Partitive Fact Types	03	3	0	0
9	Categorization Fact Types	05	5	0	0
	Total	**58**	**54**	**02**	**02**

The above table describes the Recall and precision of examples for generating EXPRESS data model. In Table 4, the average recall for SBVR software requirements are premeditated 85.30% while average precision is calculated 88.98%.

e. Results and Discussion

The normal F-value is calculated 89.90% that are empowering for introductory analyses as shown in **(Table 4)**. Here, processing of Sample 1 is shown in Section IV and the similar type of four other examples in SBVR were taken and the results of all five samples is shown in Table 4. Since, only five samples were available that has not only SBVR bus also EXPRESS model.

Table 4. Experiments results

Input	$N_{example}$	N_{True}	N_{False}	N_{error}
Sample 1	58	50	6	2
Sample 2	49	41	7	1
Sample 3	42	35	5	2
Sample 4	39	33	5	1
Sample 5	35	29	4	2

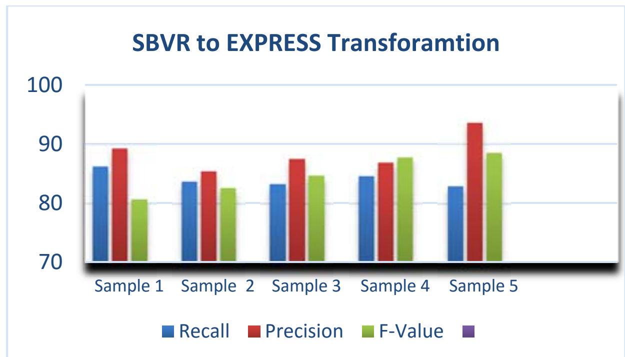

Fig 7. Results of SBVR to Express Transformation

All the processed input samples were evaluated using various evaluation metrics such as recall, precision and F-value. In this section results are calculated using above said case study and 3 more solved elsewhere, in which we calculated true entailment, false entailment and unknown entailment. Using these values we can calculate the value of recall, precision and F measure.

$$\text{Recall} = \frac{matched\ business\ rules}{total\ business\ rules}$$

$$\text{Precision} = \frac{relevent\ business\ rules}{retrieved\ business\ rules}$$

$$\text{F-measure} = \frac{2(P)(R)}{P+R}$$

The calculated recall, precision and F-measure values for the results of the performed experiments of SBVR text to EXPRESS diagram transformation are shown in **(Table 5).**

Table 5. Evaluation of the Experiments results

Input	*Recall*	*Precision*	*F-Value*
Sample 1	86.2	89.28	80.66
Sample 2	83.67	85.41	82.63
Sample 3	83.33	87.5	84.65
Sample 4	84.61	86.84	87.78
Sample 5	82.85	93.54	88.45
Average	85.3	88.98	89.9

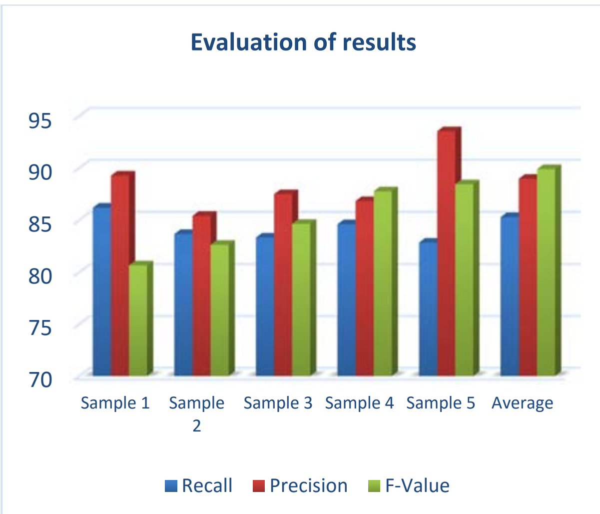

Fig 8. Evaluation of Results of Transformation

(Fig. 8) shows the evaluations of the results of the experiments and the recall value 85.3 and precision value 88.98 are quite encouraging not only for theory but also the practical application of the presented approach. It is good hope in future to measure up our outcomes to whatever other apparatus available that can produce EXPRESS information model using SBVR.

6. CONCLUSION

A challenging issue in model transformation of SBVR to EXPRESS Core Package components is addressed in this paper. To begin with issue of SBVR parsing was tended to by utilizing ordinary NLP methodologies and second issue of change of SBVR metamodel components to EXPRESS metamodel components was tended to by utilizing model change innovation. *SiTra* library was utilized with the end goal of the model change. Moreover, the mechanized article arranged investigation of SBVR particulars of programming necessities was finished. The outcomes demonstrate that the displayed methodology is a superior approach when contrasted with the other accessible methodologies. Since, no other device is available for generating EXPRESS models from SBVR or NL specifications but other available devices that can generate software and business models from SBVR or NL are in comparison with SBVR2EXPRESS device gives a lower exactness. Here, SBVR has likewise empowered to concentrate object oriented data, for example, affiliation variety, collections, speculations and occurrences as other NL-based apparatuses cannot process and concentrate this data.

(Background is of 2 pages, then 2 pages are based on the framework of the proposed approach, and Experiments, Results and Conclusion section is extended to almost 3 pages by adding are details and discussion on results)

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