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Study and Development of an Expert System for Providing Career Guidance: With Reference to Uttarakhand

Ph.D. Progress Report

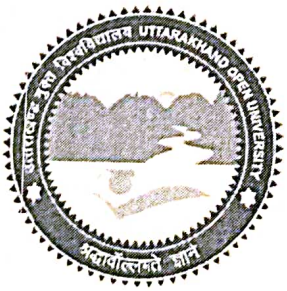
For the period

Jan 2022to August 2022

By ShilpaGunwant

Ph.D. Scholar

School of Computer Science & IT



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Objectives:

Objectives defined for the above said period (January 2022 to August 2022)were:

- Tools and techniques used to develop an Expert System.
- Collecting the information about the basic process of career counselling from the career counsellor.
- Study the factors affecting career counselling.
- Summarise the process of career counselling.
- Develop the knowledge base for the Expert System.
- Develop the rules and facts for the inference system.

2. Objectives completed:

A systematic literature review has been done, and a manuscripttitled "A Study of Expert Systems for Career Guidance" has been submitted to the journal "Journal for Learning and Development". Comments on the review paper "A Study of Expert Systems for Career Guidance" received on June 09 2022. The comments were appropriately addressed, and the manuscript was resubmitted on July 29 2022. The following table presents the status of objectives completion.

Table 1: Status of objectives completion

S. No.	Objectives	Completed (Yes/No)
1	Tools and techniques used to develop an Expert System.	Yes
2	Collection of the information about the basic process of career counselling from the career counsellor	Yes
3	Study the factors that affect career counselling.	Yes
4	Summarise the process of career counselling.	Yes
5	Develop the knowledge base for the Expert System.	Yes
6	Develop the rules and facts for the inference system.	Yes

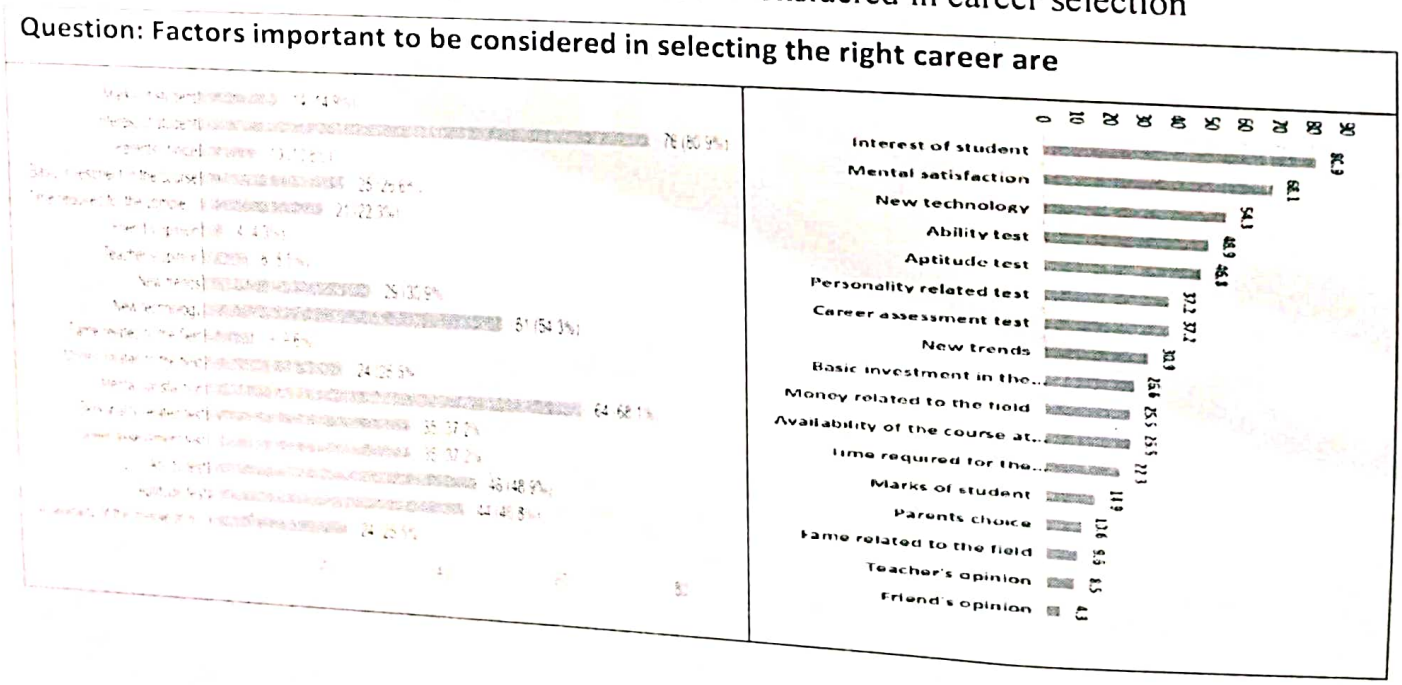
3. Description of objectives:

Careerselection is an important decision in the life of a student. This decision can provide the studentwith mental satisfaction and hence,a better life. This work is related to developing anExpert System for career selection. Thereport presents the work done in the last seven months (January 2022 to July 2022) and the work plan for the coming six months.

Based on a detailed literature survey, it has been decided that PHP technology will be used for developing the front-end. On the other hand, the backend will be developed by MySQL. XAMPP server will be used as the local host and Python 3.9 will be used for programming.

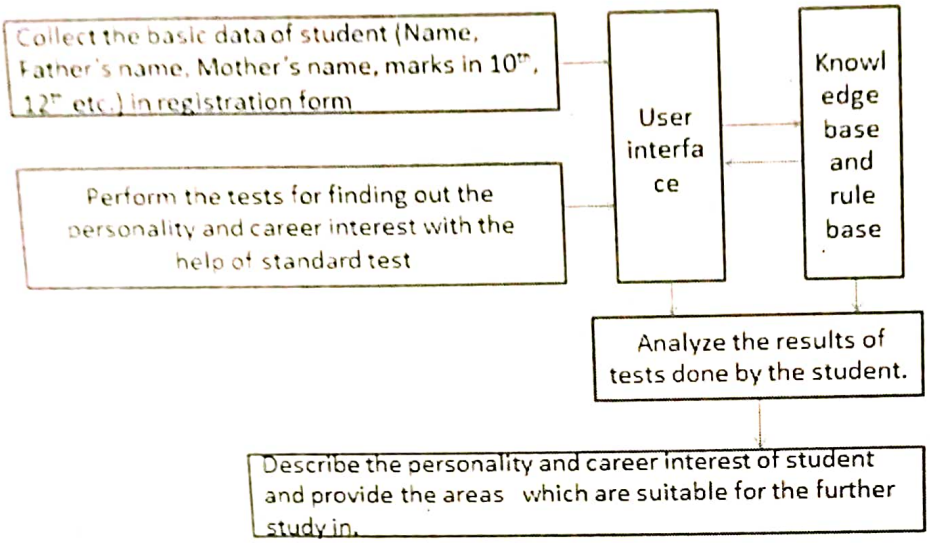
Data pertaining to the process of career counseling employed by various counselors have been collected from various primary and secondary resources. This was done to select thebasic career counseling process. Two questionnaire based surveys were also conductedto know the awareness of the career counseling among individuals from various fields. The obtained data was analyzed via Big Five test of personality assessment. The objective of the tests wasto collect data for the knowledge base.Resultsof the analysis indicate that out of 17 different factors, the interest of the student, mental satisfaction towards work, new technology, ability and aptitude test, personality and career assessment tests were most favourite of the participants. Table 2 presents the relative importance of various factors to be considered in career selection.

Table 2: Important factors to be considered in career selection



The procedure of an expert system for career selection can be summarized in the form of a flow chart.

Fig-1:Summary of the proceduretofdeveloping an expert system for career selection.



The above procedure can be explained as follows:

In the first step, the student interacts with the front-end, registershimself and entershis/her basic information. This basic information consists ofthe student's name, father's name, mother's name, occupation, marks in 10th and 12th etc. Following this, the personality and career assessment of the student will be conductedthrough a website. The results will be calculated with the help of knowledge base and rule base. The accuracy of the results will be measured with the help of feedback given by the student and career counselor suggestions after the process completion.

4. Rule Base

Big Five Personality Test helps to understand why someone act the way that they do and how your personality is structured. This test contains 50 statements and for each statement 1-50 mark how much you agree with on the scale 1-5, where1=disagree, 2=slightly disagree, 3=neutral, 4=slightly agree and 5=agree, in the box.

E = 20 + (1) ___ - (6) ___ + (11) ___ - (16) ___ + (21) ___ - (26) ___ + (31) ___ - (36) ___ + (41) ___ - (46) ___ = _____

A = 14 - (2) ___ + (7) ___ - (12) ___ + (17) ___ - (22) ___ + (27) ___ - (32) ___ + (37) ___ + (42) ___ + (47) ___ = _____

C = 14 - (3) ___ - (8) ___ + (13) ___ - (18) ___ + (23) ___ - (28) ___ + (33) ___ - (38) ___ + (43) ___ - (48) ___ = _____

N = 38 - (4) ___ - (9) ___ - (14) ___ + (19) ___ - (24) ___ - (29) ___ - (34) ___ - (39) ___ - (44) ___ - (49) ___ = _____

O = 8 + (5) ___ - (10) ___ + (15) ___ - (20) ___ + (25) ___ - (30) ___ + (35) ___ + (40) ___ + (45) ___ + (50) ___ = _____

The scores calculate should be between zero and forty. Below is a description of each trait.

• **Extroversion (E)** is the personality trait of seeking fulfillment from sources outside the self or in community. High scorers tend to be very social while low scorers prefer to work on their projects alone.

• **Agreeableness (A)** reflects much individuals adjust their behavior to suit others. High scorers are typically polite and like people. Low scorers tend to 'tell it like it is'.

• **Conscientiousness (C)** is the personality trait of being honest and hardworking. High scorers tend to follow rules and prefer clean homes. Low scorers may be messy and cheat others.

• **Neuroticism (N)** is the personality trait of being emotional.

• **Openness to Experience (O)** is the personality trait of seeking new experience and intellectual pursuits. High scores may day dream a lot. Low scorers may be very down to earth.

Fig-2: Type of personalities based on the Big Five Test

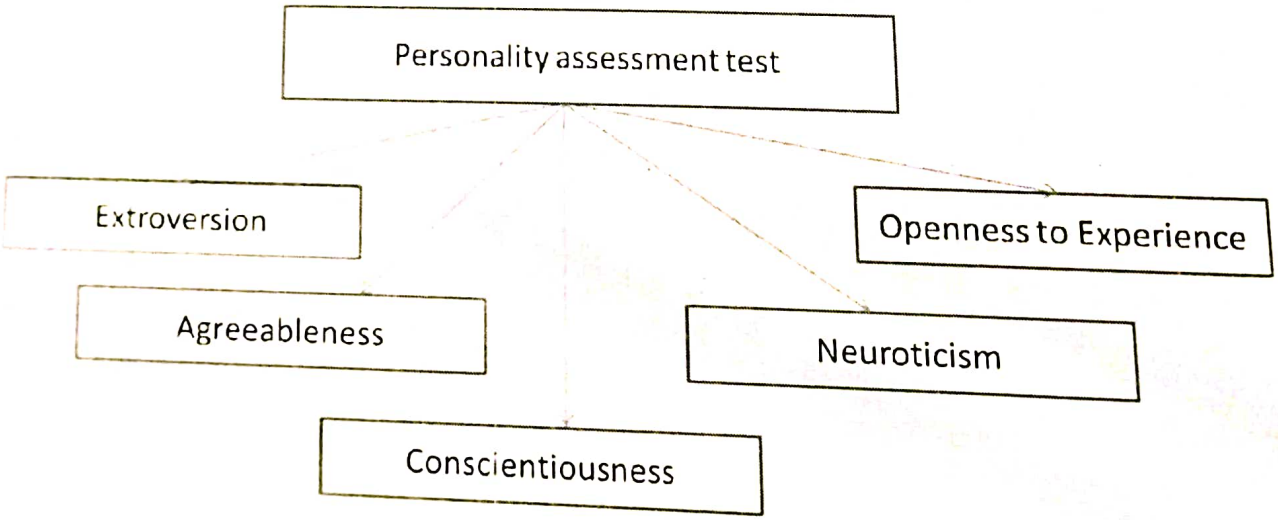


Table 3: Qualities of Particular personality and profession

S.No.	Personality Type	Qualities of Particular personality	Profession
1-	Extroversion	Enthusiastic, talkative, assertive, warmth, sociability and level of activity.	Anchors, News Presenter, Radio Jockey, public speaking, sales and entertainment
2-	Agreeableness	Kindness, cooperation, sympathy, politeness, trust and compliance.	Nursing, social work, counseling
3-	Conscientiousness	dutifulness, consistency, discipline, efficiency, attention to details, cleanliness and adherence to rules	Lawyers, doctors, scientists, engineers and CEO's.
4-	Neuroticism	anger, fear, anxiousness, depression, worry, anxiety, suspicion and self-consciousness	
5-	Openness to Experience	Creative, intellectual curiosity, imagination, adventurous, abstract thinking, sensitivity to emotions.	Entrepreneurs, artists, actors, writers, and musicians

If(Extroversion having high score)

Then

(Anchors, News Presenter, Radio Jockey, public speaking, sales and entertainment)

If(Agreeableness having high score)

Then

(Nursing, social work, counseling)

If(Conscientiousness having high score)

Then

(Lawyers, doctors, scientists, engineers and CEO's.)

If(Openness to Experience having high score)

Then

(Entrepreneurs, artists, actors, writers, and musicians)

5. Conclusion

Data collected for the knowledge base and develop the rules for system. Selected technologies are PHP for development the front-end, MySQL for backend, XAMPP for local host and python 3.9. Two surveys have been done to fulfill the objective with the aim to know the awareness for the career counseling and career assessment test. Big Five test for has been used for personality assessment of individuals. Details of attended conference have also been included in this report. One review paper is under review, attended one month internship in AI from NIT Patna via online mode. Two workshops and one FDP also completed to get explore more about technology and techniques.Next phase of six months is very important because of development will be completed. Efforts will be made to finish all the work in this period.

6. Future Plan

The objectives completed in the last six months have been mentioned. In the nextsix months it is proposed that on the basis of information collected the development of an expert system shall be completed and testing the results of expert system.Efforts will be made to publish the work in reputed journal. Chapterwriting will be started as and when the work is completed.

- Develop an Expert System for career selection.
- Testing the results of the expert system.
- Present the work in reputed journal.
- Write the chapters of work done.

7. Detail of Review Paper submission

Table 4: Details of review paper

Title of Paper	Journal	Date of submission	Date of Comments received	Date of Comments submission
"A Study of Expert Systems for Career Guidance"	Journal of Learning for Development	20-03-2022	09-06-2022	29-07-2022

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Fig-3: Screenshot of paper submission page of Journal for Learning and Development(22/08/2022)

8. Details of conference attended

Presented paper in **"Technological, Social and Economic Innovation through Artificial Intelligence, Data Science and Cyber Security" (ICTSEADC 2022)** on April 15-16, 2022 **at IMS Ghaziabad**. Presented paper and certificate of participation is attached in the progress this report at the end.

9. Details of One month Internship program

Participated in**4 weeks Internship Program Cum Training on 'Applied Machine Learning, Deep Learning & Computer Vision with Python'organized by Electronics & ICT Academies at NIT Patna** betweenJune 06andJuly 08, 2022.

Contents studied in this internship are Introduction to Python Programming, Learn how to use Python Libraries, Data Processing, Visualization & Analysis, Introduction to Machine Learning, Basics of Artificial Intelligence, Deep Learning Foundation, Computer Vision, and work upon different data sets like House price prediction, Diabetics prediction, Customer churn prediction, etc. Certificate of participation in the internship program also included with excellent performance included at the end of this report.

10. Details of workshops and FDPs

Attended one week online **workshop on "Basics of Data Science"** from April 04 to April 08 organized by **"Department of Mathematics" Graphic Era University Dehradun**. The workshop is designed for Ph.D., M.Sc., B.Sc., B.Tech., BCA, B.Sc. (IT), and B.Sc. (CS) students or other students who are interested in Data Science. Experts from industries (Tata Consultancy, Accenture solutions) and academics are invited to deliver lectures and interact with students. Topics covered in the workshop are Overview of Data Science, Conceptual knowledge of basic Statistics, Overview of different machine learning techniques, Roadmap for making career in the field of Data Science and Open discussion with experts from academics and industry.

Participated in the **SERB sponsored workshop on "Machine Learning Techniques for Signal & Image Processing Applications"**during April 18 2022 to April 22 2022 at **Dept. of Electronics and Communication Engineering, NIT Rourkela**mode of workshop was online.

Participated in the **FDP on "Artificial Intelligence and its Applications"**during July 18-28, 2022 organized by **"Vaagdevi College of Engineering, Warangal and NIT Warangal".**

Table 5: Summary of Workshop/FDP/Internship

S.No.	Workshop/FDP /Internship	Topic	University/College	During
1-	Workshop	Basics of Data Science	Department of Mathematics" Graphic Era University Dehradun	April 04 to April 08,2022
2-	Workshop sponsored by SERB	"Machine Learning Techniques for Signal & Image Processing Applications"	Dept. of Electronics and Communication Engineering, NIT Rourkela.	April 18 to April 22, 2022
3-	4 weeks Internship Program Cum Training	"Applied Machine Learning, Deep Learning & Computer Vision with Python"	Electronics & ICT Academies at NIT Patna	June 06 to July 08, 2022
4-	FDP	"Artificial Intelligence and its Applications"	"Vaagdevi College of Engineering,	July 18 to July 28,

			Warangal and NIT Warangal".	2022

Certificate of participation in both the workshops are attachedwith this report.

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For the period

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1. Introduction:

Career selection is an important decision in the life of a student. This decision can provide the student with mental satisfaction and hence, a better life and. This work is related to the development of an Expert System for career selection. The report presents the work done in the last six months and the plan of the work. In the above said period, the literature review and one paper based on the review have been completed. Theoretical study of the Expert Systems developed in the previous years in different areas like agriculture, medical, engineering, and education. As per the suggestion from the last meeting the literature review was restricted to include only the articles reporting expert system for career selection only. A systematic literature review reveals the implementation of tools and technologies as per the requirements of the end-user. Various expert systems related to teacher selection, course, major and college selection, etc. have been widely reported. A brief review of the expert systems employed for career guidance is presented below.

2. A brief review of literature on Expert System for Career Guidance

Originated at Stanford University, ES are specialized programs that derive their expertise from the knowledge of domain experts of a certain field. Interestingly, these systems were designed to extract knowledge by interviewing an expert. Generally speaking, the term 'expert system' is a software program that mimics the decision-making trait of human experts [1]. An ES is designed to be asked questions and provide a suitable explanation to the user. The extracted knowledge is used as an input for a computer program for qualitative as well as quantitative evaluation. Web-based ES have gained significantly with the advent of the internet and mobile devices which can be interconnected. This has led to significant enhancement in the accessibility of the information making it time and location independent.

The three important components of an expert system are knowledge base, inference engine, and user interface. The 'knowledge base' contains facts, rules and other knowledge that is required to solve the problem. The representation of knowledge in the 'knowledge base' is done with the help of semantic networks, frames and production rules. This knowledge is utilized by the expert system through an inference engine including the if-then rules available within the knowledge base [2].

The inference engine uses forward (known facts to resulting conclusions) and backward (hypothesis to supporting facts) chaining to search and pattern matching. The user interface is used to interact with the expert system. The two components that convert a computer program to an expert system are the knowledge base and inference engine. The

effective interconnection between these components allows obtaining the stepwise solution of specific domain problems by the human expert in a professional manner. This makes ES; knowledge-intensive software with advisory as well as solution providing capability for problems normally requiring human intervention [3].

Career guidance is a complicated yet highly significant component of an individual's life undergoing the career selection phase. It encompasses various activities such as information flow, teaching, assessing, mentoring and advising the individual for extraction of useful information about him. In other words, career guidance is a complex process involving more than one expert in an area to derive meaningful information based conclusions. The job market, being highly globalized and competitive, requires an optimum balance between immediate career selection decisions and their long-term implications. Therefore, the integration of multimedia and digital technologies has huge potential to aid the student in making a fruitful career choice. A career guidance system care must be capable of delivering generic as well as personalized guidance to students. The evolution of serious games has been instrumental in addressing this issue by adequately indulging the students and tracking the outcomes. The games have proven instrumental in extracting useful information from individuals [4].

Various expert systems based on different technologies are presented below.

2.1 Rule-based expert system:

Rule-based systems facilitate the availability of computational mechanisms which are found in most of the ES. These systems have a long history of being typically applied to varied application areas. The knowledge base of rule-based systems is represented via an agglomeration of simple and easily perceivable IF-THEN rules. These IF-THEN rules are used as inference methods ultimately employed for extracting novel logical conclusions from existing knowledge. Interestingly, equivalent logical statements can be effectively employed to represent the rules and facts in a rule-based system. The consolidation of various restrictions and language-based additional constructs, along with tight integration among language and evaluation mechanisms has significantly enhanced the advantages of rule-based systems [5].

Table 1: Summary of main rule-based ES developed for career guidance.

S. No.	Tools used	Key findings	Reference
1	Clips language and Visual basic	Software for selecting university major based on student record, ability and capability test.	[14]
2	Kappa-PC expert system environment	Intelligent decision support software for undergraduate university major search and selection.	[6]

3	Clips expert system tool	Fully automated software for selecting lecturers for teaching particular courses based on different factors.	[8]
4	Pattern matching, jSoup parsing technique	A web-based system that contains all information about all colleges in Pondicherry and student select as per their need.	[7]
5	PHP, Html, CSS, Javascript and MySql	Web-based system to transform manual process to automated process for students in pre-tertiary institutions in Nigeria, the system is implemented and tested and 76% of students given a positive response for the system.	[15]
6	PHP and CLIPS expert system tool	Web-based system for streamlining the advising process of undergraduate students, regularly monitoring the progress of the student and planning for future courses and projects.	[9]
7	SWI-Prolog, MBTI test	Career advisor expert system based on MBTI indicator Suggest students the field of career based on different personality types.	[12]
8	HTML, CSS, javascript, PHP, PHP My Admin	A web-based system that includes Talent, interest, ability, personality, knowledge and other supporting factors for providing career guidance.	[10]
9	Website development (tools not mentioned)	The course can be selected based on different factors like study time, study degree, student major, Annual student grades and annual cost.	[13]
10	Software based (tools not mentioned)	This system considers the interest evaluation test for career selection and compare that result with data already exist and provide the result.	[11]

2.2 Case-based expert system:

The case-based ES is an experience-based system employed for solving new problems via the adaptation of previously successfully solved identical problems. Case-based systems facilitate the establishment of a novel intelligent technology that can solve the problem while adapting to newer situations. It is conceptually based upon the fact that human beings solve various problems by gathering the experience. Humans generalize the patterns of cases into rules, the principal unit of knowledge being 'the case'. The reasoning is presented by associating the given problem with previous identical cases [16]. Case-based reasoning is extensively used where conventional rule-based reasoning is weaker, viz. knowledge acquisition, incomplete information-based reasoning and machine learning etc.

Table 3 presents a summary of the main case-based ES developed for career guidance

S. No.	Tools used	Key findings	Reference
1	Apache Tomcat, Java expert system shell, java database connectivity (JDBC), Java servlets.	A web-based system that helps academic staff and students of the university for selecting the right course. This system is successfully implemented experimental version in the computer science department of covenant university	[18]

2	Java-based interface, MBTI model, machine learning	Students' basic data, marks of different subjects and personality factors calculated by the MBTI model is used for career suggestion. four different modules are used in this process.	[19]
3	MATLAB based GUI	Guides the tertiary students, and the students facing problems in completion of the course and having poor performance. With Euclidean distance, the CBR algorithm achieved a 0% classification error on the test-case	[17]
4	MATLAB 7.8, GUIDE tool, SPSS 17.0.	Stand-alone system for guiding students of 10^{th} and 12^{th} in vocational interest, with the help of dataset stored in the database. 2 different techniques of AI are used classification and regression.	[22]
5	Weka pre-processing filters	Software that guides secondary level students after calculating 12 different factors using questioner. Different Machine learning algorithms viz. ID3, PRISM and PART give 100% accuracy in classification along with rules.	[21]
6	Data mining technique nearest neighbour	Multilevel career guidance was provided to students that included 11 different factors.	[20]

2.3 Fuzzy logic-based expert system:

Fuzziness pervades most of the perceptions and thinking processes of human beings. Fuzzy logic has the important capability of modelling a complex process comprising of unclear information and limited resources. The development of a career guidance expert system is an important area where strict and rigid rules would not be a truthful evaluation of the subjects. Human beings are prone to place things into categories that as not precise as well as incomplete. This solicits the need for fuzzy logic, which can represent such complicated and vague behaviour of human beings and guide them in effective decision-making.

Table 4: Summary of main fuzzy logic-based ES developed for career guidance.

S. No.	Tools and techniques used	Key Points	Reference
1	TOPSIS and fuzzy cognitive map	Career test (CT) tool for school and university students for providing better career matching. Typical and atypical factors were calculated by different tests like Holland code, five-factor model, Zi Wei, Dou, Shu and Constellation used to calculate career matching.	[23]
2	Weka tool and MATLAB	Basic data gathered through a structured questionnaire and students' class marks are 716 entries. From that 60% was used as a train set, 20% for the validation set and 20 % for the test set. For feature selection different filtering methods like Correlation-based, GainRatio, InfoGain, Relief and Symmetrical help in career selection prediction.	[24]
3	ASP.Net, MATLAB and Mamdani fuzzy model	ASP.Net, MATLAB and Mamdani fuzzy model Input values for the system are students' GPA in 9th grade, mathematics, social science and career interest taken by the questionnaire and output as a career point value. In this study correlation coefficient, confusion matrix, mean absolute error and classification accuracy were used for the	[25]

		performance evaluation.	
4	Trapezoid function to generate Membership function.	Web-based system for career counseling. Input values taken from the student's data are converted into a linguistic variable in the fuzzification process. With the help of linguistic variables, fuzzy rules have been developed and the system guides the students.	[26]
5	MATLAB and K-nearest neighbour algorithm	With 90% accuracy of this system can decide career path for students using BECE results, past academic records and personality profiles. Crisp sets are converted to fuzzy sets using the fuzzy K- nearest neighbour algorithm method.	[27]
6	The decision tree algorithms used are CART, C4.5, C5 and ID3.	This system included different modules like the maintenance module, Evaluation module, Online testing module, Test generation module, and Report generation module. After giving the test summarized result from the system will give information about in which the subject he is interested in, which proves to be a better decision for his future.	[28]
7	PROLOG and Natural language processing	The knowledge base developed with the help of both factual and heuristic knowledge. The performance of the student is judged by different aptitude tests and the inputs given by him. This system used a QUADBASE dialogue management system for the implementation of Natural Language Processing.	[29]
8	Trapezoidal membership function	The datasets were collected from the career center, Registrar, and guidance and counseling with prior approval from the schools' academic heads through a questionnaire. This study used the (RMSE) root-mean-square error and (MAE) mean absolute error to calculate the efficiency of the built fuzzy model.	[30]
9	Gaussian membership functions (GaussMf), DsigMf (difference between two sigmoidal functions) and Pi curve (PiMf)	The proposed fuzzy system is essentially a simulation of a humanoid career counselor model. The linguistic variables and their term sets, the membership functions adopted for fuzzification/de-fuzzification and the fuzzy rules form the core of the FIS. The knowledge base of the system consists of the information and data bank as well as the set of rules that guide the judgment of the experts.	[31]

2.4 Concluding remarks based on review

Various technologies viz. rule-based, case-based, data mining and fuzzy logic have been utilized for developing expert systems for career guidance. Out of these, the rule-based systems have gained popularity mainly due to the ease of use as well as design ability. Recently, with the emergence of fuzzy-logic and game-based expert systems, the applicability and efficiency of expert systems for career guidance has improved significantly. Despite the usefulness of career guidance ES, career guidance from real experts is still a recommendation.

3. Objectives:

Objectives defined for the above said period (August 2021 to January 2022) were:

- Study of the different types of Expert systems along with their application areas.
- Survey of literature regarding various applications of Expert Systems in career guidance.
- Study the existing career selection Expert System.
- Tools and techniques used to develop an Expert System.
- Difference between the technologies used in the web-based and software-based Expert Systems for career guidance.

4. Objectives completed:

Systematic literature review has been done and a paper titled "A Study of Expert Systems for Career Guidance" has been submitted to the journal "Expert Systems with Applications" published by Elsevier. Following table presents the status of objectives completion.

Table 1: Status of objectives completion

S. No.	Objectives	Completed (Yes/No)
1	Study of the different types of Expert systems along with their application areas.	Yes
2	Survey of literature regarding various applications of Expert Systems in career guidance.	Yes
3	Study the existing career selection Expert System.	Yes
4	Tools and techniques used to develop an Expert System.	Yes
5	Difference between the technologies used in the web-based and software-based Expert Systems for career guidance.	Yes

It is observed that the expert systems developed in this area are rule-based, case-based, data mining, and fuzzy logic. The majority of systems are developed with the rule-based expert system because in the rule-based it is easy to develop rules as per the need and

requirements of the user. Recently, the fuzzy-logic has emerged as an important technique for the development of Expert systems. Although, fuzzy-logic based Expert systems have found limited applications in the area of career guidance to date. It is also observed that in the case of a web-based expert system, the website development tools are used for the frontend and database development tools are used for the backend. On the other hand, in the case of software-based expert systems, software development tools are used for the frontend and database development tools are used for the backend.

5. Problem formulation

The present investigation is focused on the development of a user friendly and capable ES to help students regarding career selection and pursue suitable career paths. The developed system will be robust and scalable to various ecosystems. The system will be capable of fulfilling student needs and assist them in receiving proper and time-bound career guidance.

6. Future Plan

In the next six months it is proposed that a knowledge-base and inferences for the development of an expert system shall be developed.

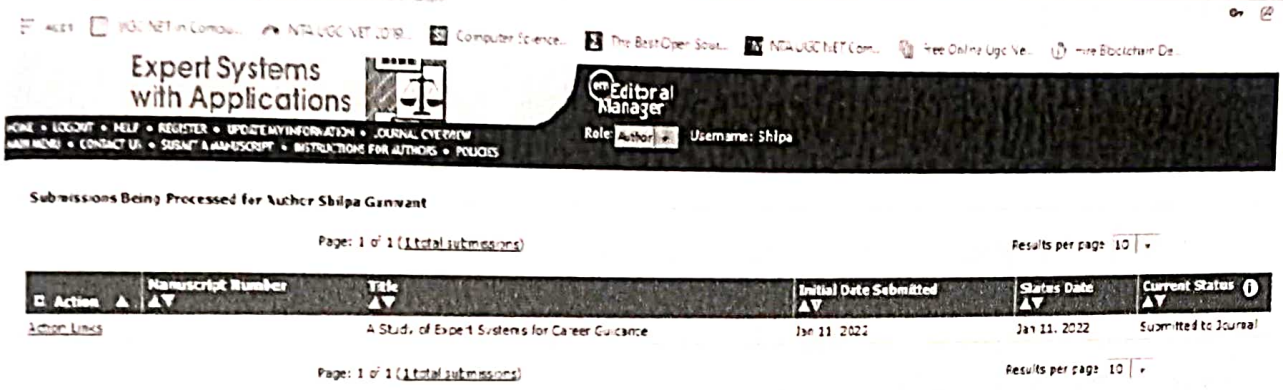
- Tools and techniques used to develop an Expert System.
- Collecting the information about basic process of career counselling from the career counsellor.
- Study the factors that affect the career counselling.
- Summarise the process of career counselling.
- Develop the knowledge base for the Expert System.
- Develop the rules and facts for the inference system.

7. Conclusion

The work of review of literature and problem formulation has been done. All the objectives which have been defined earlier are completed. The rough draft of chapter one of the thesis have been completed. In the next phase data collection for the knowledge base and inference from the career counselor will be considered. In future plan the detailed objectives are defined for further study in the next six months.

8. Detail of Review Paper submission

Title of Paper	Journal	Date of submission	Status	Cite Score/ Impact factor
"A Study of Expert Systems for Career Guidance"	Expert Systems With Application	11-01-2022	Submitted	12.7/ 6.954
"Comparative analysis of different personality tests"			Under prepration	



Expert Systems With Applications

A Study of Expert Systems for Career Guidance

--Manuscript Draft--

Manuscript Number:	
Article Type:	Review article
Keywords:	Expert systems; rule-based, case-based, fuzzy logic, data mining, artificial neural network
Corresponding Author:	Shilpa Gunwant Uttarakhand Open University Haldwani, Uttarakhand INDIA
First Author:	Shilpa Gunwant
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Abstract:	In recent decades, the role of expert systems (ES) for career guidance has evolved tremendously. These systems have managed to provide the remotest student with the ability to make intelligent decisions as far as their career choice is concerned. This article presents a systematic review of ES developed for career guidance, course selection and evaluation of students in the past ten years. We categorize different ES on the basis of the technologies used in their development. Various ES developed for career guidance such as rule-based, case-based, fuzzy logic etc. have been reviewed. These systems utilize several factors contributing towards career selection viz. personality, preferences, marks, talents, career interests, and skills for providing accurate guidance. The review identifies relatively high weightage given by the researchers to the rule-based systems owing to their simplicity and wide applicability.

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