THE UNDERWRITER

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Project 1 - EXPERT SYSTEMS

INTRODUCTION AND BACKGROUND

The job of a mortgage underwriter is to evaluate all of the factors that are relevant to the consideration of a mortgage loan for a potential home buyer and determine whether or not they are qualified. Income, credit history, debt, and the mortgage amount itself are some of the most important considerations the underwriter takes into account when deciding whether to approve or deny a loan request.

The system we have developed aims to provide the user (a potential home buyer) with a prediction of how an underwriter might evaluate a loan application they may be considering. The system intends to simulate the mortgage underwriting process by evaluating the major factors involved in the decision process in a similar way to an actual underwriter.

A system that can perform this complex task effectively would improve the home buying process by allowing the potential home buyer to be more informed before applying for a mortgage loan. Instead of applying for a mortgage blindly, a potential buyer can get an unlimited number of risk-free assessments from the system before finally preparing to going through the, often, stressful probing process.

The Underwriter system aims to give a potential loanee an educated guess as to the decision they will receive for their mortgage loan application.

KNOWLEDGE ENGINEERING

Our project expert is Eyasu Mulatu, a real estate broker with over 12 years of experience selling real estate in the Sacramento area. Eyasu owns and runs *EM Realty Group*, a residential real estate brokerage that operates in the Sacramento area (including Placerville and Yolo County). Eyasu's rich background with the real estate world makes him the perfect expert to model our fuzzy system after. His input and advice clarified the process significantly and provided enough depth to allow the creation of our expert system.

Eyasu graduated from CSUS with a Business degree in 2004 before getting a job with a home builder company called *Sycamore Homes*. He worked as a project manager, dealing with land acquisition, development and construction of over 200 homes per year. After seven years with *Sycamore Homes*, Eyasu became a realtor (sales) with *Lake Vista Real Estate Group*, working as a contractor under their brokerage firm. In 2010, Eyasu acquired his brokers license and opened *EM Realty Group*, where he oversees 4 licensed realtors under his brokerage. Eyasu also has experience as a real estate investor and has purchased and sold dozens of homes over the years.

At *EM Realty Group*, there is daily communication with individuals representing lending institutions like loan officers, underwriters, appraisers, direct lenders and asset managers. The relationships Eyasu has built with many has helped him to develop a keen insight into how the process works from the inside. In total, Eyasu has been directly involved in over 150 real estate purchases and over $35 million in mortgage loans.

For our project, we began our knowledge engineering by asking Eyasu what the loan approval process looks like. Eyasu explained how the customer submits a loan application with general information to the loan officer at a bank and a back-and-forth begins between both parties as the loan officer requests additional information in the form of pay stubs, tax forms, etc. Once the loan officer has collected all of the pertinent information, he/she will package it together and pass it on to a mortgage underwriter. The mortgage underwriter is the one who is given the power by the lending institution to determine whether a potential borrower is qualified to receive a loan. The underwriter looks at the numbers in the data presented, and, if their data presented is adequate, makes a decision on behalf of the lending institution regarding that mortgage loan application.

We soon realized that *underwriting* was the “brains” of the loan application process and decided that it would lend itself to being turned into an intelligent fuzzy system. We began to zero in on the underwriting process in order to flesh out the factors in an underwriter’s evaluation and see if we could find places to fuzzify the system. An underwriter looks at the obvious numbers like a potential borrower’s credit score, income and existing debts, but alongside those numbers they also look at data regarding employment history and bank statements to help them determine the likelihood that a person is capable of paying back the loan. On one level, there’s the

expected number crunching and statistics, but on another level, the underwriter also takes a holistic view of the borrower to make their decision.

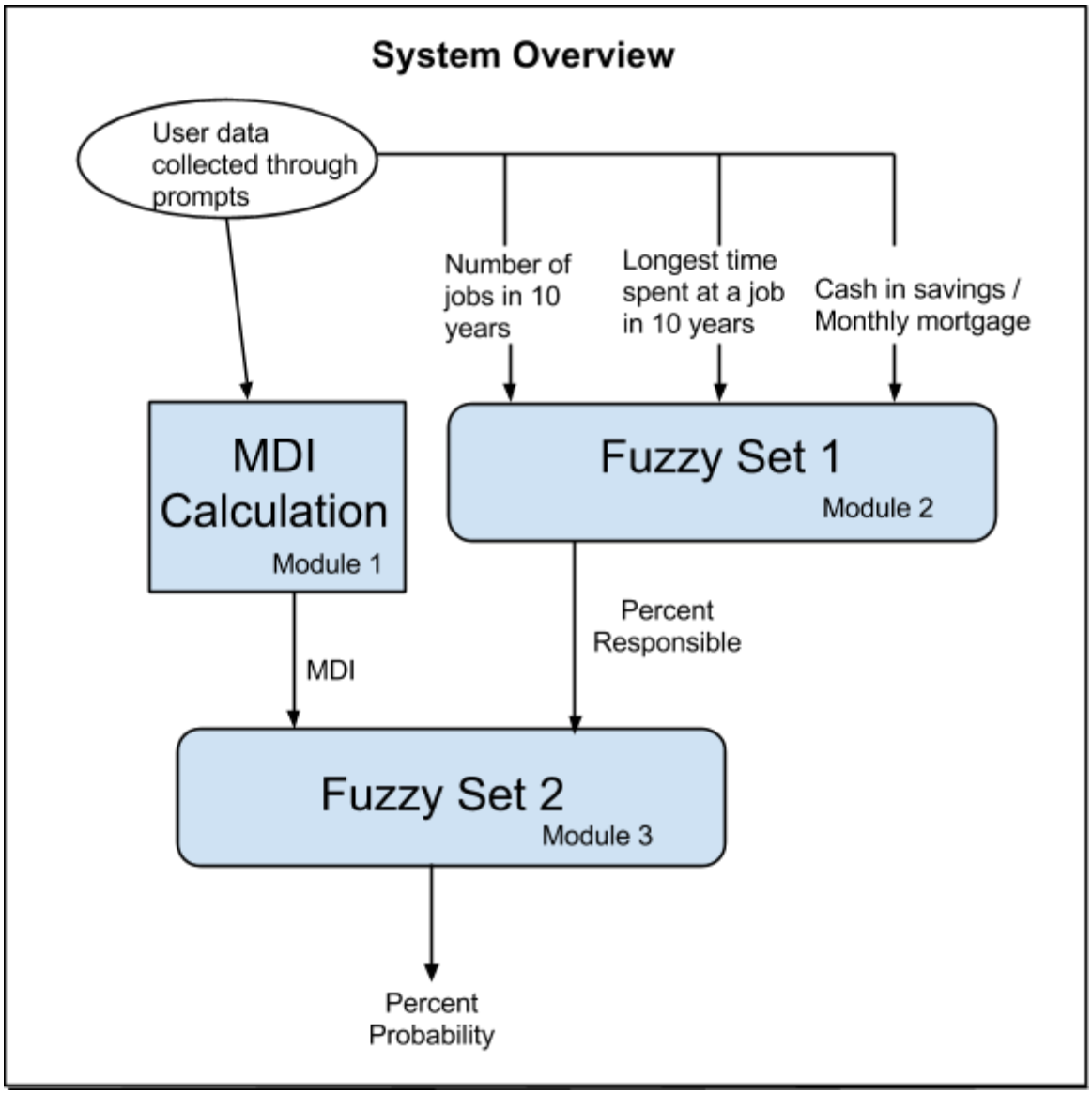
As we set out to design this fuzzy system, we were forced to place constraints in order to successfully capture the core decision making process. To begin with, we decided to have the system request the prospective borrower's desired mortgage amount and, after requesting additional data, provide the user with the likelihood that they would be approved for that loan amount as a percentage. In actuality, the customer applies for a loan and the underwriter is the one who decides not only if they are approved for a loan but gives them a specific dollar amount that they have been approved for. We also constrained the system to only work for individuals who have an employer (apart from themselves). The initial plan was for the system to branch and incorporate a scenario where the applicant is self-employed, but Eyasu advised us against that, since the evaluation process for a self-employed person is very nuanced and would be cumbersome to try and codify into a system. Another constraint we put on the system is a fixed 30-year mortgage term. Usually, once the underwriter approves a person for a mortgage amount, the borrower is able to choose from a list of different terms (eg. 15-year, 25-year, 30-year, etc) with monthly payments varying accordingly. We also decided to model the system around the mortgage approval process for a conservative institution, which wouldn't take risks like some smaller institutions might. Further constraints that came about as we designed the system are described in the conclusion of the report.

EXPERT SYSTEM DESIGN

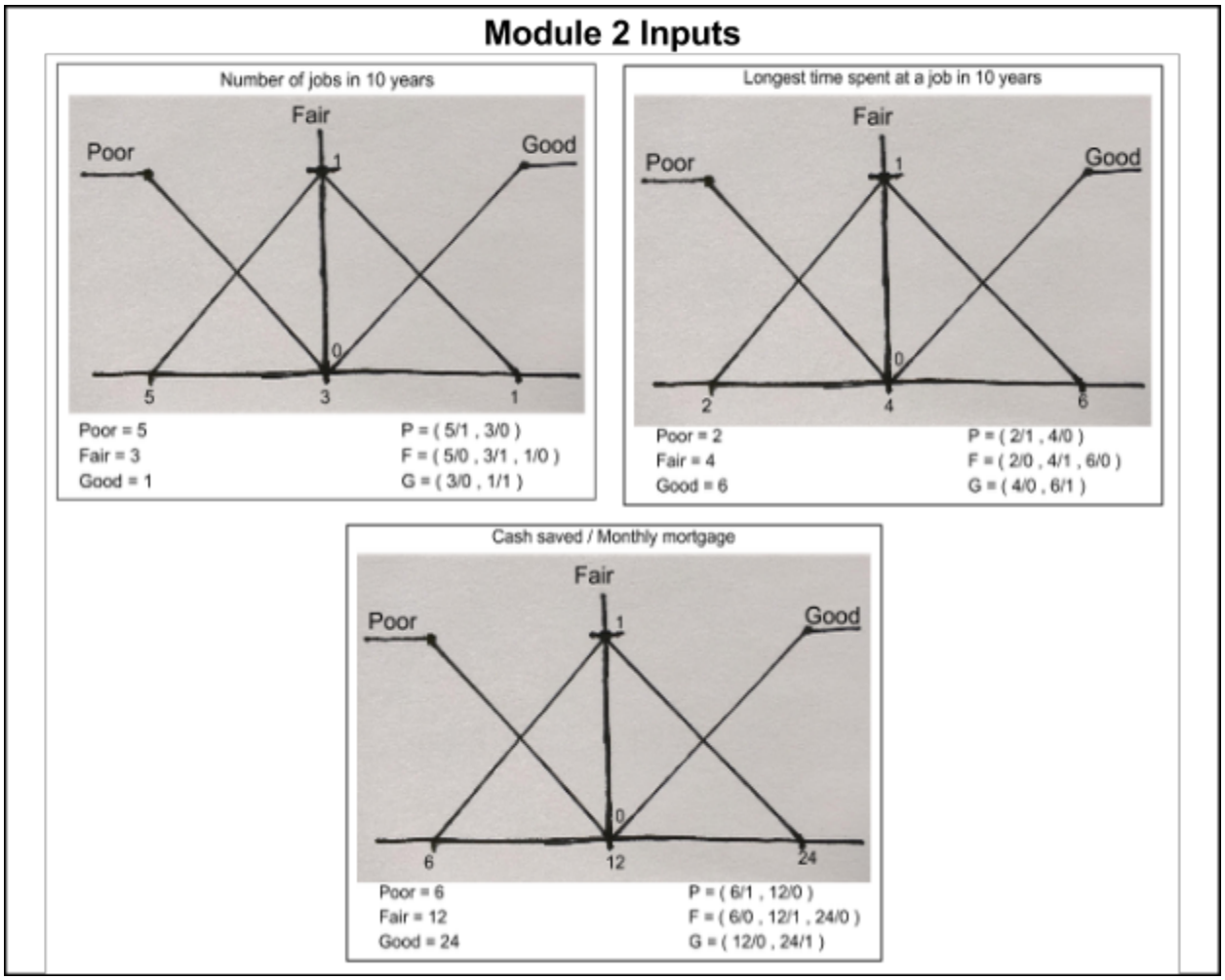
As we began to categorize the data the underwriter takes into consideration, we decided to lump the information into two categories that the underwriter is most concerned about: the numbers with regards to income and debts, and the borrower's reliability to follow through for the duration of the loan term and avoid foreclosure. While crisp numbers like income and debt amounts are easy to compute and quantify, it isn't immediately clear how things like employment history, for example, translate into a borrower's *mortgage worthiness* that can be quantified; but the trained brain of an underwriter makes decisions based on "fuzzy" factors like this daily.

We decided that our overall system would take the two categories we created and turn them into a quantifiable measure of how likely the user is to get a mortgage based on the inputs they entered. We separated the system into three modules (see "System Overview" diagram below). The first module is *not* fuzzy, and simply takes in all of the required user information, such as: the user's age, desired mortgage amount,

income, debt, and credit score. This module then comes up with a decimal value we call an *MDI* (Mortgage Debt Income ratio). The second component takes three factors that an underwriter might take into consideration to determine a user's reliability and runs them through a fuzzy system that outputs a percentage we call the user's *Responsibility*. The three factors considered are the amount of money the user has saved in the bank, the number of jobs they've had in the past 10 years, and the time, in years, of the job they've worked the longest over the last 10 years. The third module is also fuzzy and takes the outputs of the first and second modules and, using it's fuzzy logic, converts them into a percentage that represents the probability that a user will be approved for the loan they requested.



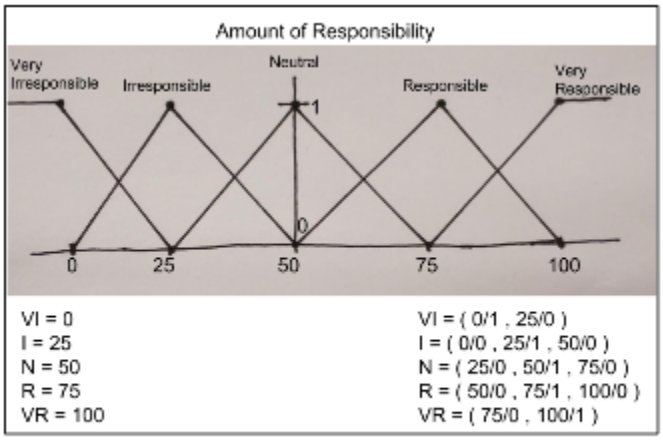
In order to implement our system in CLIPS, we created approximately 100 rules which handle user input, perform basic calculations and navigate the system through our logical tree. The program starts off with zero ‘deffacts’ and builds its ‘fact’ base from the user’s response to specific prompts. Some examples of these rules include user age, user job, downpayment value and whether or not the user can afford it, loan type branching, mortgage calculations, interest rate calculation based on loan type and current values, tax information including income and debt, as well as the fuzzy rules pertaining to the FAMs generated by modules 2 and 3 described above.



To calculate the MDI value output by Module 1, the system computes the ratio of the user’s monthly mortgage bill plus their existing monthly debts to their gross monthly income. This is one of the computations that lenders perform and they are looking at to see that the ratio is under 0.45. The user declares whether they can afford a 20% down payment, and if so, qualify for a “conventional loan” with a specific interest rate (dependent on their credit score). If the user can’t pay the 20%, they are offered a 3.5%

down payment, which qualifies them for an FHA loan that has slightly higher interest rates and an insurance fee tacked onto the monthly mortgage payment. The user's monthly mortgage bill is computed by taking their principal mortgage amount (after subtracting their down payment), adding the interest over the life of the loan term and the taxes, converting the value to a monthly value and potentially adding on mortgage insurance if the type of loan the user qualifies for is FHA. The interest applied to the loan is calculated based on current market values depending on the user's credit score and what type of loan they qualify for (FHA or Conventional).

Module 2 Output



VI = 0	VI = (0/1 , 25/0)
I = 25	I = (0/0 , 25/1 , 50/0)
N = 50	N = (25/0 , 50/1 , 75/0)
R = 75	R = (50/0 , 75/1 , 100/0)
VR = 100	VR = (75/0 , 100/1)

Output ranges of "Responsibility"

Cash Good

NUMBER \ TIME	G	F	P
G	VR	VR	N
F	VR	R	I
P	R	N	I

Cash Fair

NUMBER \ TIME	G	F	P
G	VR	N	I
F	R	R	I
P	R	N	VI

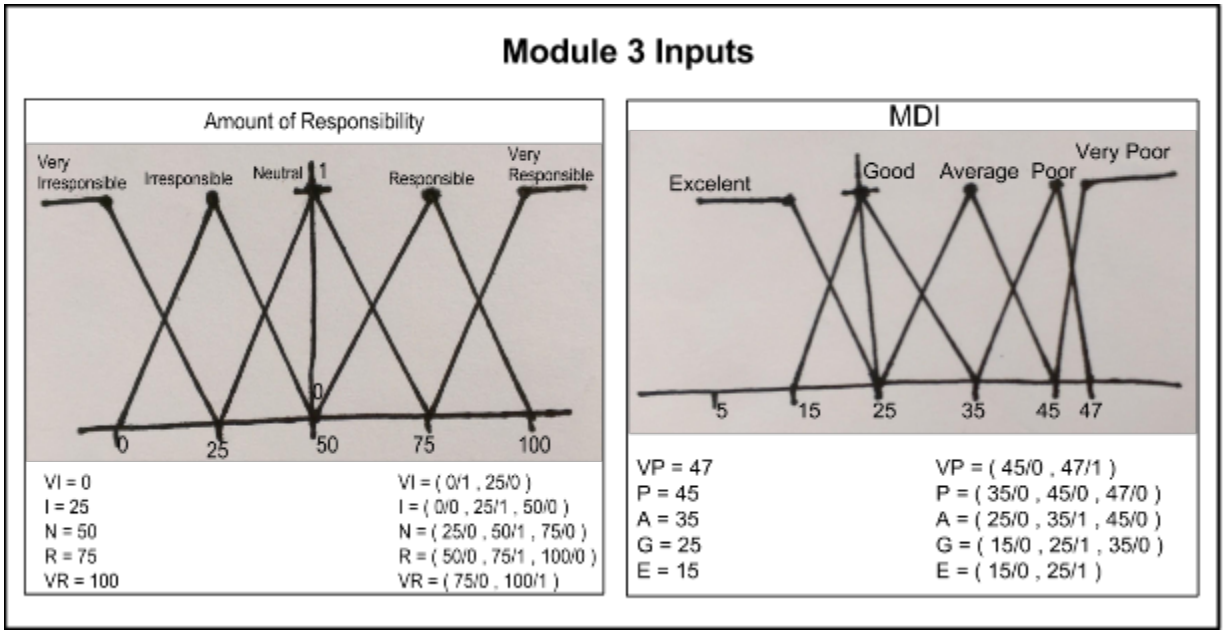
Cash Poor

NUMBER \ TIME	G	F	P
G	R	N	I
F	R	N	VI
P	N	I	VI

FAM for Module 2 (Responsibility)

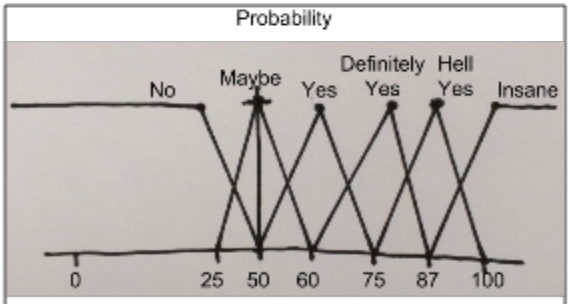
To compute the Responsibility value for Module 2, the system takes three inputs from the user: the amount of money they have saved up, the number of jobs they've had in the past 10 years, and the length in years of the longest job they've held during that same timeframe. The amount of money saved is converted into the number of months of mortgage payments it would cover. The system also takes the other two

inputs using the ranges specified in the diagrams below. The system designates all three inputs as Poor (P), Fair (F), and/or Good (G). The resulting 3 x 3 FAM labelled “First Fuzzy System” shows the weightings of the different fuzzy inputs on the crisp responsibility value. The system outputs a responsibility percentage that falls into the categories Very Irresponsible (VI), Irresponsible (I), Neutral (N), Responsible (R), and Very Responsible (VR).



To compute the Probability of getting the loan the system must now tie both the MDI and Responsibility together using the final fuzzy component. This component takes the two percentage (decimal) inputs, *fuzzifies* them, and comes up with a single probability output. The MDI value is categorized as Excellent (E), Good (G), Average (A), Poor (P), Very Poor (VP). Our system has a very sharp transition from Poor to Very Poor because of the hard cutoff that conservative lenders make at an MDI value of 0.45. The Responsibility value is now received in five evenly-distributed categories: Very-Irresponsible (VI), Irresponsible (I), Neutral (N), Responsible (R), and Very-Responsible (VR) The fuzzy system takes both of the inputs and outputs Probability. These input weights are displayed in the 2 X 2 FAM. The FAM output categories are No (N), Maybe (M), Yes (Y), Definitely Yes (DY), Hell Yes (HY) and Insane(I) and the final value is presented to the user as a nice, crisp percentage.

Module 3 Output



N = 25
M = 50
Y = 60
DY = 75
HY = 87
I = 100

N = (25/1 , 50/0)
M = (25/0 , 50/1 , 60/0)
Y = (50/0 , 60/1 , 75/0)
DY = (60/0 , 75/1 , 87/0)
HY = (75/0 , 87/1 , 100/0)
I = (87/0 , 100/1)

RESPONSIBLE	MDI				
	E	G	A	P	VP
VR	I	HY	DY	M	N
R	I	DY	DY	M	N
N	I	DY	Y	M	N
I	HY	Y	Y	M	N
VI	HY	Y	Y	N	N

Here is a sample run:

Fail

```
o--------------------------------------o
|                                      |
|     Mortgage Pre-Aproval System      |
|        by Nati Tessema and           |
|          Javier Garrido              |
|                                      |
o--------------------------------------o

Please complete a few questions about yourself:

|--Are you over 18? (yes/no) yes
|
|--Do you have a job? (yes/no) yes
|
|--Have you been at your current job for
|  more than 6 months? (yes/no) no
|
-----------------------------------------------------------------

                        Sorry,
  You cannot get a mortgage if you haven't been at
    your current job for more than 6 months.
```

Success

```
o--------------------------------------o
|                                      |
|     Mortgage Pre-Aproval System      |
|        by Nati Tessema and           |
|          Javier Garrido              |
|                                      |
o--------------------------------------o

Please complete a few questions about yourself:

|--Are you over 18? (yes/no) yes
|
|--Do you have a job? (yes/no) yes
|
|--Have you been at your current job for
|  more than 6 months? (yes/no) yes
|
|--Enter the amount you want for the
|   mortgage: (ex 400000) 250000
|
|--Can you afford a downpayment of 50000.0
|   (20% of  your desired mortgage)? (yes/no) yes
|
|--What is your credit score? (620-850) 720
|
|--What is your gross income per month? (ex 3000) 6000
|
|--What is your debt per month?  (ex 300) 250
|
|--How many jobs have you had in the last 10 years? 2
|
|--How long did you hold your longest job in the last 10 years? 5
|
|--How much money do you have saved up? (ex 30000) 30000


------------------------------------------------------------

      The loan type you qualify for is: conventional.

      You are considered 77.97619047619048 % responsible

      There is a 84.00957059235331 % probability that
               you get the mortgage.
```

CONCLUSION

The approach that we took seems to work rather well. The system recognizes the MDI cutoff point where lenders choose not to take a risk and drastically drops the users probability of getting a loan. When users enter favorable amounts of saved cash or have higher income to debt ratios they get high percentages as we'd expect to see. Conversely, too much debt gives a user a very low probability of being approved for the loan. A system that takes more fuzzy inputs might be more accurate, but a higher level of uncertainty may still muddle the input processing.

These are some of our known limitations:

- The system only takes into account three factors when determining a person's responsibility: cash saved, time at longest job (past 10 yrs), and number of jobs held (past 10 yrs). In actuality, there are many factors that an underwriter considers but for the purposes of this program we chose to focus on those we thought most relevant and could quantify.
- The mathematical calculations our system takes into account are a bit more simplistic (out of necessity) than those used in real life. We only take into account the MDI value while lending institutions clearly have many more calculations that they take into account.
- Interest rates are hard coded into our system but they fluctuate daily in actuality.
- The system doesn't take into account that different lenders are geared towards varying levels of risk, so we target the most conservative lenders (usually large banks).
- The system only handles the two major types of loans: FHA and Conventional. Other types of loans and lenders exist, but those are less common and apply mostly to extreme cases.
- The system doesn't take into account that there are exceptions to almost every rule. As an example, if the underwriter sees that a person's MDI is slightly over 0.45 they can look further into the person's information to find more evidence of their reliability.
- The system can never truly be said to be 100% accurate because there is fairly significant variance in the decision making, not only due to different lending institutions, but also because of different underwriters themselves!
- Since the inputs the user provides are simple inputs that get put through several calculations to reach the desired MDI, some inputs might generate values that are out of the fuzzy system range because they are invalid. There are no checks or warnings letting the user know about this fact. The only time the user might run into an issue like this would be when they enter unreasonable values. Values that result in edge cases are accounted for, since our system includes some cushioning for the fuzzy values. Only extreme values will cause an error.

Ultimately we believe The Underwriter system is good at simulating the underwriting process. It doesn't quite have the intelligence of an actual underwriter but it "thinks" along the same lines when evaluating the same core input. With more rules and a bit more precision the system can become more and more accurate. The future is sure to be full of systems similar to this one that can further remove humans from simple enough processes like this one and allow for full automation.

APPENDIX A - INSTALLATION GUIDE

1. Copy this link
   http://athena.ecs.csus.edu/~gordonvs/180/180homework.html

2. Paste it into your browser of choice

3. About halfway down the page on the left side there is a link titled "Fuzzy CLIPS"

4. Click the link and a download will begin

5. Navigate to your downloads folder and look for the zip file that downloaded. It should be called "fzclp610d.zip"

6. Unzip the file

7. Navigate to fzclp610d\pc-prjct\VC++\fzClips\fzclipswin\Release\fzclipswin.exe and double click the .exe file to open CLIPS

8. Open the File menu on the top left and select "Load Constructs"

9. Navigate to where you have our program folder and select "the underwriter.clp"

10. You should see a ton of rules loading into CLIPS with a "TRUE" at the end

11. Type in " (reset) " and press enter

12. Type in " (run) " and press enter

13. Follow the prompts and enter the information that is asked

APPENDIX B - USER'S GUIDE

- No need to enter any Deffacts
- Data is entered through a series of prompts that start when you run the program (Follow Installation Guide to get the program running)
- If you are unsure of what to enter there are some examples at the end each of the prompts in parenthesis
- After you finish inputting all the information requested, the program will let you know what type of loan you are eligible for (FHA or Conventional) and percentage that represents how likely you are to get the mortgage you requested. It also provides a percentage letting you know how responsible you will appear to the underwriter who looks at your application

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