Case study 3: Decision-support fuzzy systems

I want to develop an intelligent system for assessing mortgage applications. Will a fuzzy expert system work for this problem?

Mortgage application assessment is a typical problem to which decision-support fuzzy systems can be successfully applied (Von Altrock, 1997).

To develop a decision-support fuzzy system for this problem, we first represent the basic concept of mortgage application assessment in fuzzy terms, then implement this concept in a prototype system using an appropriate fuzzy tool, and finally test and optimise the system with selected test cases.

Assessment of a mortgage application is normally based on evaluating the market value and location of the house, the applicant's assets and income, and the repayment plan, which is decided by the applicant's income and bank's interest charges.

Where do membership functions and rules for mortgage loan assessment come from?

To define membership functions and construct fuzzy rules, we usually need the help of experienced mortgage advisors and also bank managers, who develop the mortgage granting policies. Figures 9.7 to 9.14 show fuzzy sets for linguistic variables used in our problem. Triangular and trapezoidal membership functions can adequately represent the knowledge of the mortgage expert.

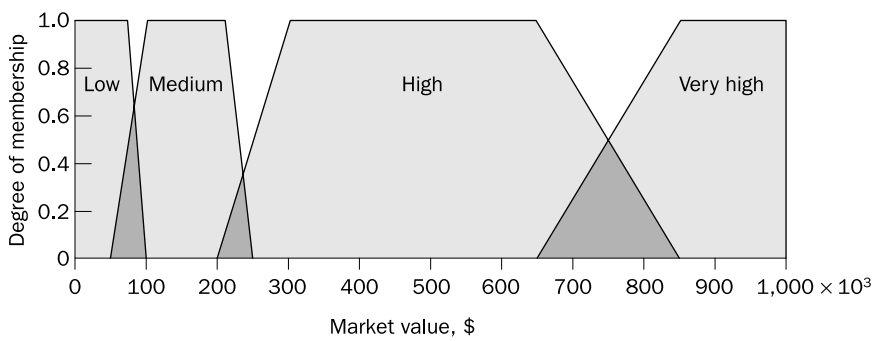

Figure 9.7 Fuzzy sets of the linguistic variable *Market value*

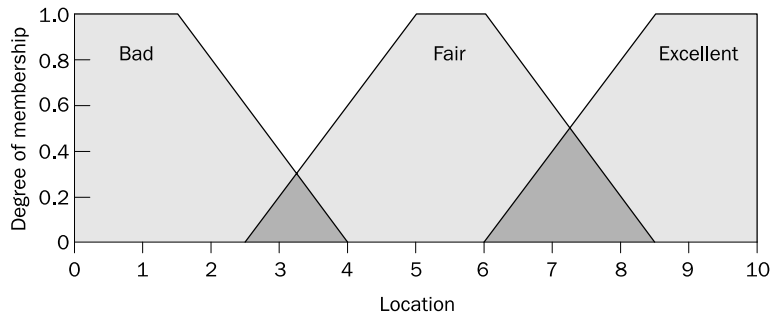

Figure 9.8 Fuzzy sets of the linguistic variable *Location*

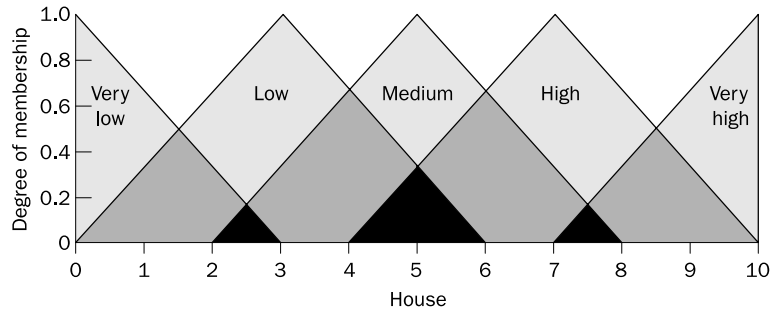

Figure 9.9 Fuzzy sets of the linguistic variable *House*

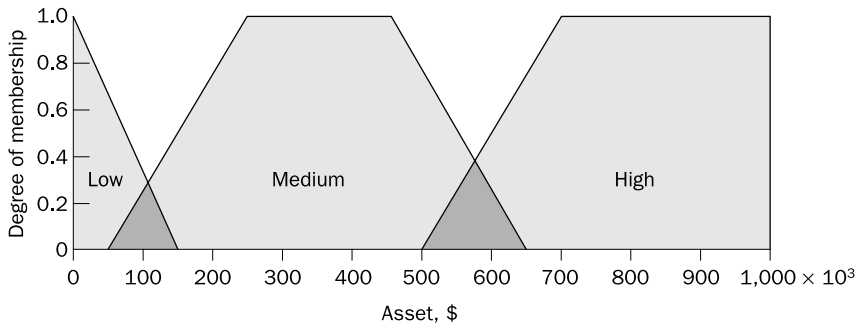

Figure 9.10 Fuzzy sets of the linguistic variable *Asset*

Figure 9.11 Fuzzy sets of the linguistic variable *Income*

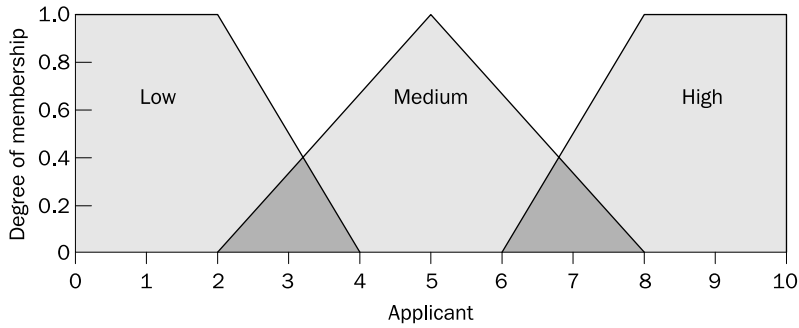

Figure 9.12 Fuzzy sets of the linguistic variable *Applicant*

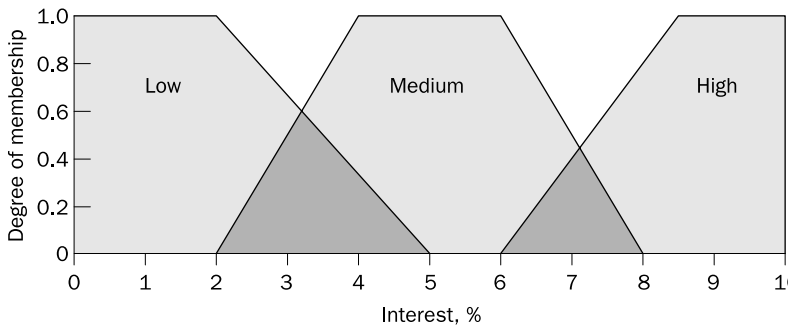

Figure 9.13 Fuzzy sets of the linguistic variable *Interest*

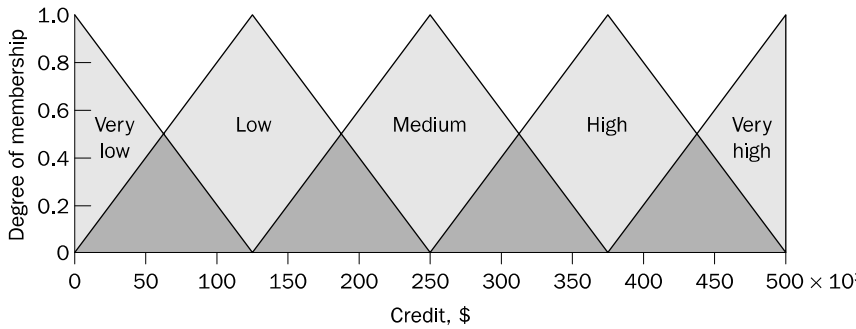

Figure 9.14 Fuzzy sets of the linguistic variable *Credit*

Next we obtain fuzzy rules. In our case, we simply adapt some of the basic rules used by Von Altrock in his fuzzy model for mortgage loan assessment (Von Altrock, 1997). These rules are shown in Figure 9.15.

Complex relationships between all variables used in the fuzzy system can be represented best by the hierarchical structure shown in Figure 9.16.

To build our system we use the MATLAB Fuzzy Logic Toolbox, one of the most popular fuzzy tools currently on the market.

The last phase in the development of a prototype system is its evaluation and testing.

Rule Base 1: Home Evaluation

1. If (Market_value is Low) then (House is Low)
2. If (Location is Bad) then (House is Low)
3. If (Location is Bad) and (Market_value is Low) then (House is Very_low)
4. If (Location is Bad) and (Market_value is Medium) then (House is Low)
5. If (Location is Bad) and (Market_value is High) then (House is Medium)
6. If (Location is Bad) and (Market_value is Very_ high) then (House is High)
7. If (Location is Fair) and (Market_value is Low) then (House is Low)
8. If (Location is Fair) and (Market_value is Medium) then (House is Medium)
9. If (Location is Fair) and (Market_value is High) then (House is High)
10. If (Location is Fair) and (Market_value is Very_high) then (House is Very_high)
11. If (Location is Excellent) and (Market_value is Low) then (House is Medium)
12. If (Location is Excellent) and (Market_value is Medium) then (House is High)
13. If (Location is Excellent) and (Market_value is High) then (House is Very_high)
14. If (Location is Excellent) and (Market_value is Very_high) then (House is Very_high)

Rule Base 2: Applicant Evaluation

1. If (Asset is Low) and (Income is Low) then (Applicant is Low)
2. If (Asset is Low) and (Income is Medium) then (Applicant is Low)
3. If (Asset is Low) and (Income is High) then (Applicant is Medium)
4. If (Asset is Low) and (Income is Very_high) then (Applicant is High)
5. If (Asset is Medium) and (Income is Low) then (Applicant is Low)
6. If (Asset is Medium) and (Income is Medium) then (Applicant is Medium)
7. If (Asset is Medium) and (Income is High) then (Applicant is High)
8. If (Asset is Medium) and (Income is Very_high) then (Applicant is High)
9. If (Asset is High) and (Income is Low) then (Applicant is Medium)
10. If (Asset is High) and (Income is Medium) then (Applicant is Medium)
11. If (Asset is High) and (Income is High) then (Applicant is High)
12. If (Asset is High) and (Income is Very_high) then (Applicant is High)

Rule Base 3: Credit Evaluation

1. If (Income is Low) and (Interest is Medium) then (Credit is Very_low)
2. If (Income is Low) and (Interest is High) then (Credit is Very_low)
3. If (Income is Medium) and (Interest is High) then (Credit is Low)
4. If (Applicant is Low) then (Credit is Very_low)
5. If (House is Very_low) then (Credit is Very_low)
6. If (Applicant is Medium) and (House is Very_low) then (Credit is Low)
7. If (Applicant is Medium) and (House is Low) then (Credit is Low)
8. If (Applicant is Medium) and (House is Medium) then (Credit is Medium)
9. If (Applicant is Medium) and (House is High) then (Credit is High)
10. If (Applicant is Medium) and (House is Very_high) then (Credit is High)
11. If (Applicant is High) and (House is Very_low) then (Credit is Low)
12. If (Applicant is High) and (House is Low) then (Credit is Medium)
13. If (Applicant is High) and (House is Medium) then (Credit is High)
14. If (Applicant is High) and (House is High) then (Credit is High)
15. If (Applicant is High) and (House is Very_high) then (Credit is Very_high)

Figure 9.15 Rules for mortgage loan assessment

To evaluate and analyse the performance of a fuzzy system, we can use the output surface viewer provided by the Fuzzy Logic Toolbox. Figures 9.17 and 9.18 represent three-dimensional plots of the fuzzy system for mortgage loan assessment. Finally, the mortgage experts would try the system with several test cases.

Decision-support fuzzy systems may include dozens, and even hundreds, of rules. For example, a fuzzy system for credit-risk evaluation developed by BMW

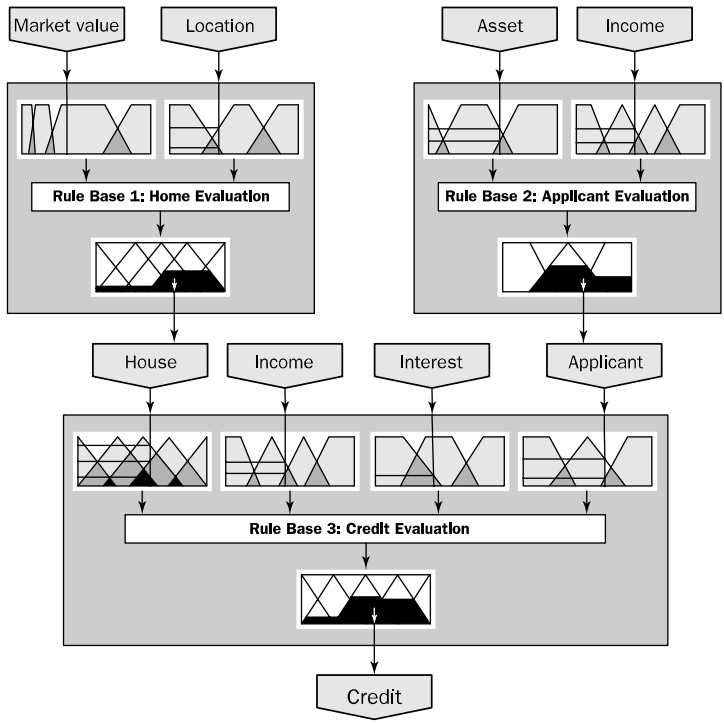

Figure 9.16 Hierarchical fuzzy model for mortgage loan assessment

Bank and Inform Software used 413 fuzzy rules (Güllich, 1996). Large knowledge bases are usually divided into several modules in a manner similar to that shown in Figure 9.16.

In spite of the often large number of rules, decision-support fuzzy systems can be developed, tested and implemented relatively quickly. For instance, it took just two person-years to develop and implement the fuzzy system for credit-risk evaluation. Compare this effort with the 40 person-years it took to develop MYCIN.

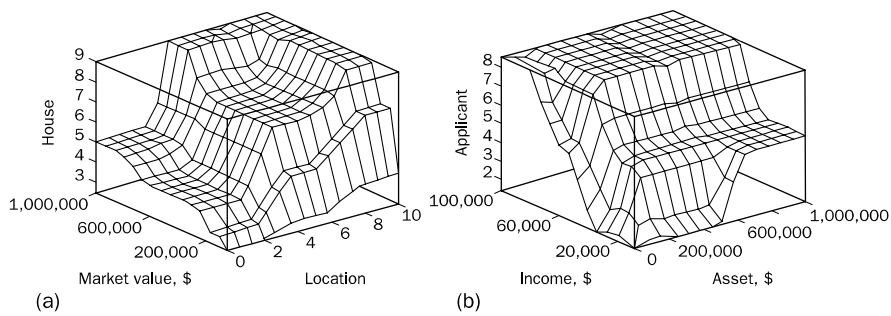

Figure 9.17 Three-dimensional plots for Rule Base 1 and Rule Base 2

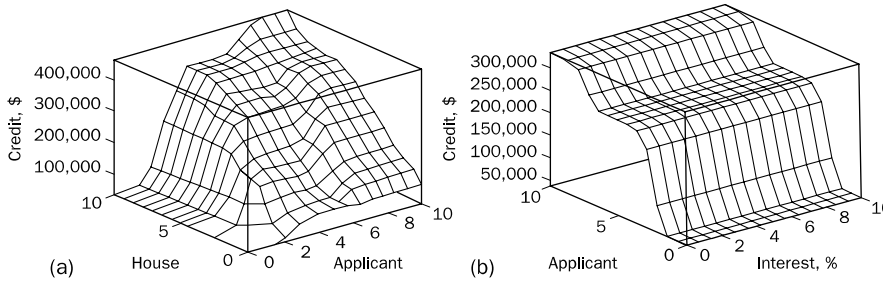

Figure 9.18 Three-dimensional plots for Rule Base 3