A Fuzzy Logic-based Approach to Producing Health Care Services Recommendations

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Structure of presentation…

- Health Care Service Quality Challenges
- Health Care Recommender Systems
- Introduction to User Generated Content (UGC)
- UGC in tourism
- Applying Fuzzy Logic and Multicriteria to analyzing UGC
- Future Research

Health Care Quality Challenges- I

- Achieving higher level of heath service quality, the common success criterion for the different types of services or e-services, requires the adoption of a patient focused approach, paying particular attention to customization and personalization.

Health Care Quality- Challenges- II

- Indeed, the application of personalization technologies in the design and provision of e-health services is a key determinant for its success, as health is a very personal matter requiring focused information, privacy and security.

- However, the acquisition of patient information is one main obstacle in the successful implementation of prenasalised services due to privacy concerns.

Health Care Quality- Challenges- III

- With the shift from curative to preventive health concerns by patients, e-health will need to empower subjects in the decision-making and management of their own health status through better choices.

- This is leading to a new generation of systems to support informed decision-making and high-quality provision of care.

Health Care Quality- Challenges- IV

- The electronic health records system (EHR), being adopted in many countries as the basis for the recording of patient medical data, can assist the delivery of personalized healthcare and health information.

- However, EHR adoption requires commitment to meet specific patient requirements, e.g., availability, access, security, usability, support of future services.

Health Care Quality- Challenges- V

- NHS in the UK, offers a free health portal that provides high quality health information and advice 24 hours a day and is recognized. It is organized in the following **six sections** allowing information and advices to be delivered in a personal way:

Health Care Portal provide the following types of Services

- *Health encyclopedia:* provide access to a full range of information.
- *Common health questions:* provide useful information based on the questions of interest to the public.
- *Self-help guide:* based on a personal identification of symptoms through an A-Z or a body key reference and a set of yes/no questions, advice is given to the public on how to get treatment.
- *Mind and body magazine:* provide the public with latest health news and health-related issues affecting them.
- *Send a health enquiry:* allow people to make specific requests for information and receive a personal response.
- *Find a local health service:* allow people to find the nearest health services based on their postcode.

Recommendation Systems (RS) in Health Services

Health Care (RS)

- To provide such services in a personalised manner raise the need to develop recommender systems in the healthcare sector for both the patients and the medical staff.

Health Care RS domains

- Food recommendations
- Drug recommendations
- Health status prediction
- Physical activity recommendation
- Healthcare professional recommendations (patients can find the right doctors to build a trust relationship)

Health Care RS Research Challenges

- Constructing user profiles
- Early disease detection
- Persuasive recommendations
- Health expert question-answering services
- Evaluation of health recommender systems

Health expert question-answering (HQA) services

- Recently, (HQA) services (systems) have attracted more patients to ask health-related questions everywhere at any time due to the convenience and effectiveness.

- However, the quality of answers in existing HQA systems varies in different situations.

Health expert question-answering (HQA)

- Answers are usually written in short text with partial information, which yields the data sparsity issue, and the important context information may be under-utilized.
- Community information, such as the best answer and the number of users' votes, cannot be provided. This information is helpful to determine high-quality answers.

Introduction to Patient Generated Content (PGC)

PGC

- PGC refers to any type of content (e.g. blogs, website pages, images, social media posts, and testimonials) that is created and published by patients.
- PGC may include: feedback reviews, questions asked, issues raised, answers received, etc.

Proposed Framework:

Produce healthcare recommendations by utilising of DEMATEL and Fuzzy Logic to analyse Patient Generated Content.

Methodology steps I

1. **Select all documents** published by patient (i).

2. **Identify the terms** that express patient (i) preferences regarding tourism services that user(i) has consumed.

Methodology steps II

3. **Calculate** the Term Frequency (TF) for each identified term.

Methodology steps III

4. **Calculate the weight of each term** using the following formula:

$$W_{tk} = TF_{tk} * log \frac{N_i}{d_{tk}}$$

Where W_{tk} represents the weight of term t_k, TF is the term frequency, Ni is the total number of documents published by user (i) and dtk represents the number of documents that contain term t_k.

Methodology steps IV

5. **Apply the DEMATEL multicriteria method.**
6. **DEMATEL assumes the interrelationships among concepts. The proposed framework assumes the conditional probabilities that one concepts appears provide that another appears too. Thus, the DEMATEL assumes the Pr(A/B), for each concept.**

DEMATEL: Step 1

- The average matrix of conditional probabilities.

$$Z = [z_{i,j}], i, j \in SDD$$

- Where SDD is the Service Domain Dimension that represent all concepts that have been found in all patient reviews.
- $z_{(i,j)}$ indicate the conditional probabilities.

DEMATEL: Step 2

- **Calculate the normalized initial direct- relation matrix D:**

$$D = \lambda * Z$$

$$\lambda = \min\left[\frac{1}{\max\sum_{j=1}^{n}(z_{i,j})}, \frac{1}{\max\sum_{i=1}^{n}(z_{i,j})}\right], \quad where 1 \le i \le n, 1 \le j \le n$$

DEMATEL: Step 3

- Derive the total relation matrix T:

$$T = (I - D)^{-1}$$

- Rows show the concepts that appear provided that the concept on the row appears in a review.

DEMATEL: Step 4.1

- Calculate the sums of rows and columns of matrix T

$$r = r_i[r_{i,j}]_{nx1} = (\sum_{j=1}^{n} t_{i,j}), \qquad c = c_j[c_{i,j}]_{1xn} = (\sum_{i=1}^{n} t_{i,j})$$

- The value of r(i) indicates the total given, direct and indirect effects.
- The value of c(j) shows the total received, direct and indirect effects.

DEMATEL: Step 5

- **Set a threshold value (α)**

$$a = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}(t_{i,j})}{N}$$

- Where N is the number of elements of T matrix.

DEMATEL: Step 6

- Build a cause and effect relationship diagram, by mapping all coordinate sets of

$$(r_i + c_i, r_i - c_i)$$

- which indicate
- Importance the most concepts and
- the probabilities of concepts to appear together.

Assume the following Healthcare service concepts found in reviews

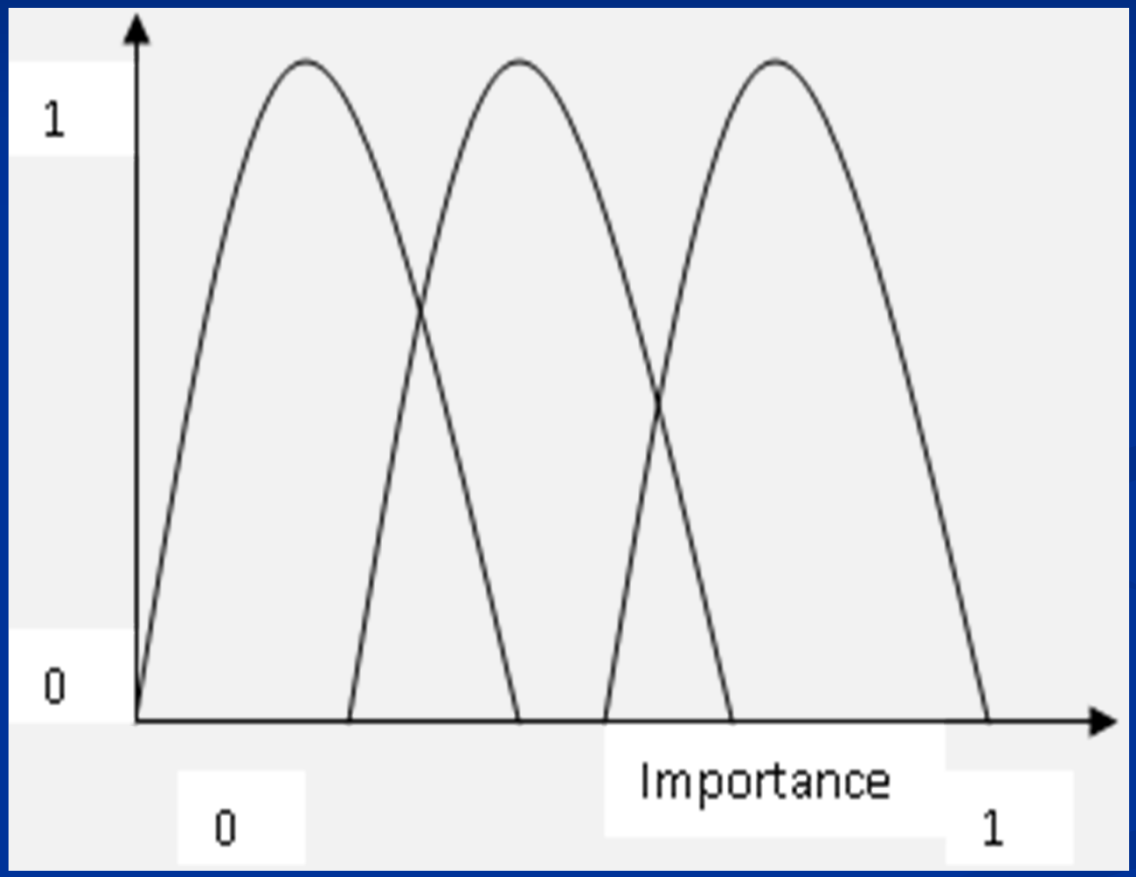
- Cost (C) of the service
- The time of service completion (t).
- The number of medical examinations.
- The diagnosis accuracy (DA).
- The friendliness of staff (F).
- The service environment (SE).

Example of DEMATEL T matrix

	PQ	C	t	NEx	DA	F	SE
PQ	0	0	0	0	0	0	0
C	-0.8	0	0	0	0	0	0
t	-0.8	+0.6	0	0	0	0	0
NEx	+0.7	+0.5	+0.6	0	+0.8	0	0
DA	+0.9	+0.4	0	0	0	0	0
F	+0.7	0	0	0	0	0	0
SE	+0.8	+0.7	0	0	0	0	0

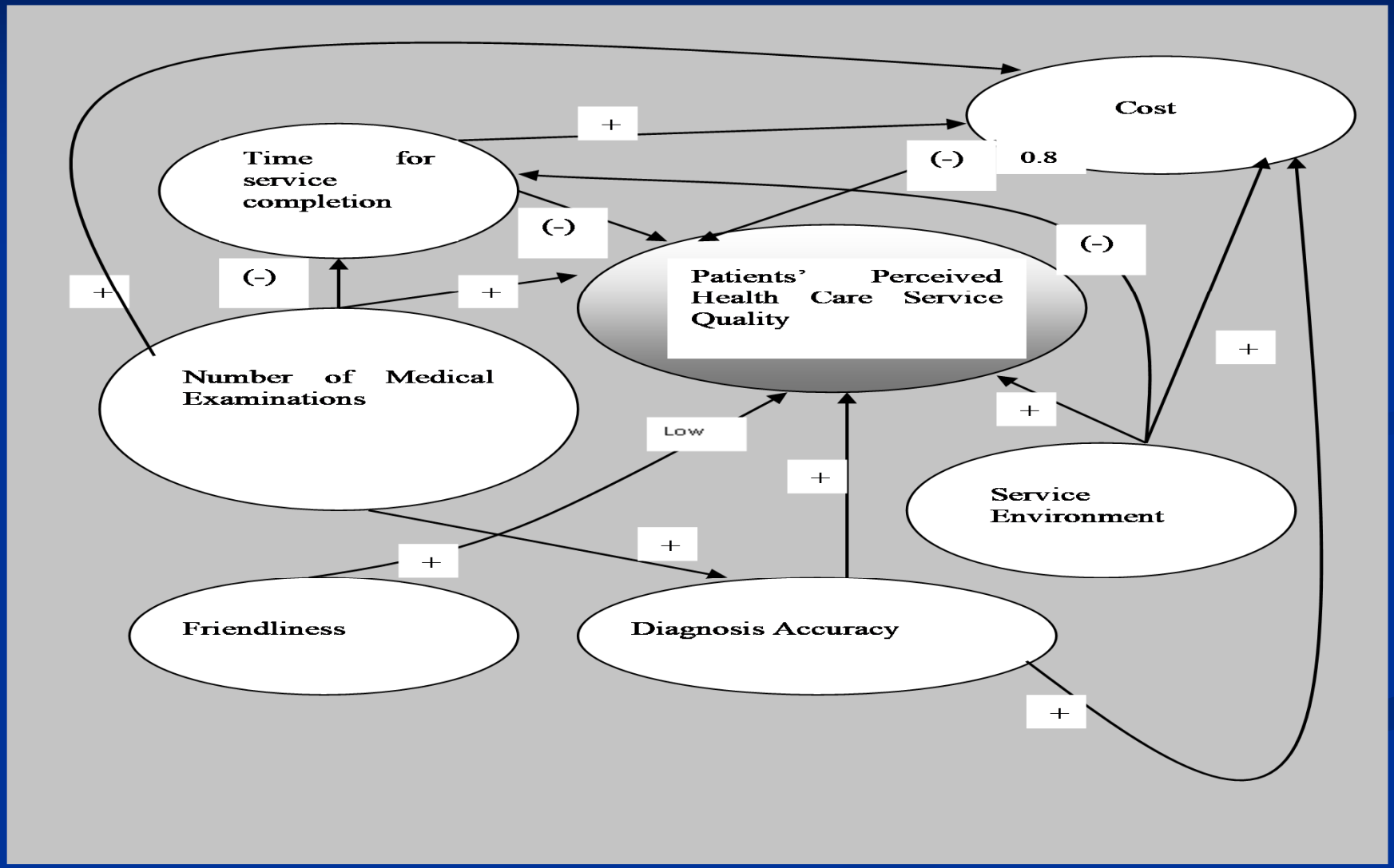
Values in cells indicate the conditional probabilities concepts to appear in a review

Constructing the Fuzzy Cognitive Map



The fuzzy cognitive map that represents a patients preferences, is designed using the High, Medium and Low linguistic variables.

The DEMATEL derived Fuzzy Cognitive Map



Time considerations…

Each review regarding a feature was published by patient (pi) at a point in the time: T_y^{pi}.

Time values are fuzzified.

Fuzzy Time

Very Old	(0, 0.1, 0.25)
Old	(0.15, 0.3, 0.45)
Neutral	(0.35, 0.5, 0.65)
Recent	(0.55, 0.7, 0.85)
Very Recent	(0.75, 0.9, 1)

Recommendations (R) are calculated by simulating the FCM, taking into consideration the preference (P), and the time (T) for each review made by patient (p)

$$R_y^{pi} = P_y^{pi} * T_y^{pi}$$

Future Research

Future research

- To introduce Sentiment (S) analysis.
- To refine the formula by using patients' feedback to evaluate recommendations.

References

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Thank you!!!