

New Developments in Fuzzy Sets, Intuitionistic Fuzzy Sets, Generalized Nets and Related Topics Volume II: Applications

Editors

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**Systems Research Institute
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Warsaw 2012

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Systems Research Institute
Polish Academy of Sciences
Newelska 6, 01-447 Warsaw, Poland
www.ibspan.waw.pl
ISBN 83-894-7541-3

Dedicated to Professor Beloslav Riečan on his 75th anniversary

Modelling consumer needs

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Abstract

This paper describes how consumer and his/her needs can be modelled. Presented is how consumption processes can be structured. Explained is how consumer behavior is determined by felt needs and what conditioning shall be included while modelling one's choices. Named are consumption limitations that would be taken into account. Presented is also an overview of how we would proceed with our research using the space of consumers and the space of products.

Keywords: needs, Maslow, Alderfer, Murray, preferences, consumer.

1 Introduction

Consumer - a basic economic entity is motivated by various stimuli. Consumer behavior, which directly corresponds to purchasing, is conditioned by his widely understood environment. Evaluation of these motives has been in the scope of interest of many sciences, starting from psychology, ending at economics. A lot has been done but there is still a lot to do. In reference to the current state of knowledge in the area of consumer needs theory, we would like to investigate further aspects of human motivation, and especially how different sorts of relations, dependencies and similarities between various types of needs, consumption restrictions and other types of environmental conditioning can be modelled.

New Developments in Fuzzy Sets, Intuitionistic Fuzzy Sets, Generalized Nets and Related Topics. Volume II: Applications (K.T. Atanassow, W. Homenda, O. Hryniewicz, J. Kacprzyk, M. Krawczak, Z. Nahorski, E. Szmidt, S. Zadrozny, Eds.), IBS PAN - SRI PAS, Warsaw, 2012.

2 Consumer needs theory

The most elementary consumer activity - purchasing is driven by the force of needs and aims at satisfying certain deficiencies. From the point of view present in contemporary economics, needs have to be studied as they create market demand. Humans perform certain maximizing or minimizing operations in order to achieve a maximum level of satisfaction under given environmental conditioning, [1]. Nevertheless marked shall be that there is no such a possibility to satisfy all needs, as needs are unlimited. New needs are being constantly created, sometimes naturally, along with the progress of mankind, but most of the time, needs are created by sales specialists, whose job is to convince us about certain deficiencies.

As insatiable appetite for new experiences is a natural attribute of a human being, satisfying needs have to be discussed in contrast with existing limitations. These restrictions could be traced back to both internal and external factors. Empirical research prove that there is a natural hierarchy - or rather natural dependencies between human needs. Certain natural, inborn, sometimes even subconscious beliefs make us prioritize deficiencies and satisfy them in a certain order or to a certain, even controlled extent. Through the years several needs hierarchies have been developed. Some of most prominent names among researchers devoted to the human motivation research are: Abraham Maslow, Henry A. Murray and Clayton Alderfer. In the paragraphs below described are needs taxonomies developed by named authors.

2.1 Maslow's Hierarchy of Needs

The most widely recognized needs theory has been developed in the 1940's by Abraham Maslow, an American psychologist, [7]. Maslow's theory is based on 5 groups of motivations that determine human's actions. Maslow's theory states that these needs are prioritized. At the bottom of Maslow's needs pyramid are most fundamental factors, like food or sleep, while at the top placed are needs that evolve around personal development. Satisfying a higher level need, could be done only after all recognized lower level needs had been satisfied, at least minimum level. Figure 1 presents Maslow's needs hierarchy.

Physiological needs are the basic part of human motivation. They include food, breathing, clothing and other elements required by human's organism to function correctly. These are the most primary factors, which have to be provided prior to any other needs. What has to be marked though, is that Maslow's theory has been based and is valid only for mentally and physically healthy human beings. Disturbed individuals may have unsettling perception of what stimuli



Figure 1: Maslow's needs hierarchy

shall exert the greatest impact on one's behavior, hence needs prioritizing may be unsettled.

Second from the pyramid's bottom is the group of safety needs, which include all factors necessary to assure secure existence, including personal and financial safety, health and other insurances. Safety needs derive from a conscious conviction that every species is susceptible to many threats connected with natural processes of ageing and to various unexpected accidents.

Love and belonging needs follow needs of safety. According to Maslow, love and belonging needs express a natural striving for maintaining permanent emotional relationships with other humans. We express these feelings by having friends and family, participating in religious groups, forming formal and informal associations or identifying with a nation or a minority.

Fourth level in Maslow's needs hierarchy is taken by esteem needs. We seek appreciation and recognition from the environment. Moreover, we aim for self-complacency.

Named four groups of needs have a deficiency character. Maslow perceives their motivating nature as a stimuli that arise when an entity starts to sense insufficiency. In other words, deficiency needs stimulate a homeostasis response, aiming at compensating disturbed state of equilibrium. Nevertheless, presented theory admits that there are certain needs that can be classified ambiguously, [4]. For example, the need of association can be explained both as a will to form relationships between a group of people and as a way to gain respect.

At the top of described needs hierarchy placed are self-actualization needs.

They comprise of motivation to express oneself and to aspire for the full potential. Maslow underlines that self-actualization needs, in contrast to all lower level needs, could be called "being" needs or "metaneeds", [5]. They do not express a will to minimize some shortage, but to develop alternate dimensions of a human being - such as realizing one's dreams or discovering one's vocation. Naturally, self-actualization needs could be substantially different for different people. Moreover, it is significantly more difficult to clearly recognize what exactly is the self-actualization stimuli that is the driving force. Hence, Maslow underlines that that "self-actualization...rarely happens (...) certainly in less than 1% of the adult population", [4]. The same author believes that achieving such a level of personal development implies one's independent thinking, righteous judgements and other virtues.

In later years presented needs hierarchy has been repeatedly reviewed and applied. Nevertheless, original Maslow's hierarchy still constitutes the basic theory of human motivation.

2.2 Murray's Theory of Psychogenic Needs

A different approach to the needs theory has been developed by Henry A. Murray in the USA before the II World War. According to this theory, human's behavior is being explained by two types of motivations: primary and secondary, [7]. First group consists of visceral factors, which are identical to Maslow's physiological and safety needs. These are for example: food, breathing, rest, sleep, clothing and shelter. Secondary needs, according to Murray, have psychogenic character and comprise of 6 sub-groups:

- needs connected with inanimate objects (having, keeping, creating, organizing, keeping in order),
- needs that express one's ambitions, strong will, desire to achieve, understand and excel,
- needs of surrender or objection to higher powers (domination, autonomy, submissiveness, excuse),
- desires to harm oneself and others (needs of: isolation, rejection, humiliation, aggressiveness, exhibitionism),
- needs of relationships (respect, acceptance, care, nurture, association),
- additional needs that evolve around society (information, teaching, play).

Murray's theory, similarly to Maslow's, does not provide a clear directions of how to assign various motivations into given groups and sub-groups. Acceptable is certain level of ambiguity and some needs may belong to two or more groups at the same time. The most noticeable element in Murray's work is acknowledging that needs can be expressed both consciously and sub-consciously. For example, the need of aggression may be expressed by watching violent movies. Murray's needs theory has been one of the first widely appreciated and recognized research in the area of motivation. Many later researchers, including Maslow, have been inspired by his achievements, which were especially noticeable in the area of psychological stimuli analysis.

2.3 ERG Model

Motivation theory developed in 1969 by Clayton P. Alderfer provides third, widely recognized needs taxonomy, namely the ERG model. ERG's foundation and inspiration was Maslow's needs hierarchy. Alderfer divided human needs into three groups:

- Existence (which include all needs that contribute to one's survival: food, rest, breathing, safety etc.),
- Relatedness - a will to create and maintain relationships,
- Growth, which comprises of self-development needs, [7].

Dividing human needs into these three groups reflects dependencies occurring between various motivations. At the most fundamental level in Alderfer's taxonomy placed are existence needs. They correspond to physiological and safety needs from Maslow's hierarchy. Relatedness needs match love, belonging and partially esteem needs from Maslow's taxonomy. Growth needs correspond to Maslow's self-actualization and self-esteem needs.

The main difference between Alderfer's and Maslow's theories is that the first author underlines that relatedness and growth needs can be satisfied simultaneously. The only priority is to satisfy existence needs. Moreover, individuals may sense different motivations with various intensity. Alderfer's theory states also, that a human being who has failed in satisfying needs from higher groups may replace unfulfilled higher-level needs with lower-level needs. That means, instead of aspiring for one's potential, people may decide to satisfy more basic needs, like having relationships. These dependencies act also in the opposite direction. An individual, who is successfully satisfying lower-level needs feels encouraged to satisfy higher-level needs.

Since there is unlimited amount of needs, all three groups from ERG model may contain unlimited amount of elements. Individual preferences determine, which needs would be satisfied.

3 Developed approach to consumer needs theory

Our further research on consumer needs modelling is based on Alderfer's ERG model. We have resigned from other needs taxonomies, as the ERG model presents the highest level of universality. For example, Maslow's theory is valid only for developed countries. There is also an opened discussion on Maslow's needs classification. Some researchers believe, that several types of needs are not correctly assigned to their respective groups. Third reproach for Maslow's hierarchy is that it does not allow to pass over any lower-level needs before satisfying higher-level needs. Murray's needs theory, on the other hand, does not focus on all aspects of human being, concentrating mainly on heterostatic type of motivation. Both Murray's and Maslow's needs theories are valid for societies comprising mainly from individualistic entities, while Alderfer's model can be also applied for more collectivistic societies. Hence, while looking for repetitive patterns in household consumption data, we will probably rely on the ERG model.

Developing a theoretical model of consumer needs requires defining a set of restrictions on an unlimited set of needs. The smallest level of consumption describes such a set of satisfied needs that assures entity's survival. On the other hand, maximum level of consumption of some good is reached when consuming any additional amounts of a good or a service has a negative effect for the individual. In other words, the maximum level of consumption is when satisfaction from consumption of the next unit of good turns into dissatisfaction. In the real world objective factors that may naturally limit consumption are: time (time flow), space (you cannot visit Paris and Tokyo at the same time), organism properties (ability to digest food or to read books), etc.

Apart from natural barriers that discourage consumption and define its maximum level, other limitations must be taken into account. In a situation when these other factors require to choose only one type of good (or service) and resign from others, rational consumer evaluates and makes a decision based on his or her preferences, [10]. Consumer's choice theory is in fact discussing how various decisions affect one's satisfaction. As measuring satisfaction is not a straightforward task, in economics it is calculated only for one individual. Moreover, satisfaction cannot be scaled and discussed separately. Instead, we compare satisfaction from consumption of two different goods (or baskets of goods). As preferences are crucial to understanding consumer's behavior, it is worth to mention that we usually

do not describe it as some crisp or strictly evaluatable experience. As a result, similarly as we calculate opportunity costs, the choice of a need, which we would satisfy over others is dependent on subjective assessment of how much more happiness and contentment would this particular choice bring or to what extent a particular choice makes us happy or unhappy.

Uniqueness of human race makes it very difficult to unambiguously divide people and assign them identical needs. Hence, an important task appears, to find some common denominators in a group of people. Distinguishing individuals with similar preferences would allow us to describe them by similar consumption choices. As a result of such a division, received would be several sets representing people with at least partially convergent preferences. These sets would have interdependencies. Each identity included in the model would be represented by a vector of needs. Such a vector, indefinite in its size, would contain all needs, sorted sequentially, so that first would come needs of existence, second - relatedness and third - growth (order compliant with the Alderfer's ERG model). Each of vector's element would inform about the amount of product or service consumed by the individual, whose consumption is being described by the particular vector during given period of time.

As needs can be satisfied with various products and services, many goods are used to do so. Moreover, various conditions determine that different people may use different products to satisfy the same need. The differences that may appear, happen because of many conditions, including financial, social or cultural factors. Especially regarding the growth needs, the choices may seem to be highly varied.

To sum up, modelling consumer needs, basing on the ERG model, would proceed by developing a vector of needs that would be later assigned to some number of individuals, so that each considered person would own one vector. Each vector would contain information about one's consumption during given period of 1 year. Values in vectors would be varying from between the minimum level of consumption and the maximum level of consumption.

In order to model how consumption (unlimited in its nature) is restricted by various conditions, considered would be several types of limitations, including:

- natural - arising from human needs, space, time, biological or psychological limitations,
- social - arising when an individual builds relationships and associates with various social groups,
- financial - arising when earnings do not allow us to satisfy all felt needs.

Our approach to consumer needs modelling could be illustrated by the following example.

Discussed are chosen needs from the ERG model and several products and services that satisfy them. Taken into consideration (for the sake of the example) are:

1. Existence needs:

- sleep - to satisfy this need one gets for example: bed, pillow,
- food - to satisfy this need one gets for example: bread, pork, cottage cheese, salad,
- drink - to satisfy this need one gets for example: drinking tap water, water filter, mineral water, spring water,
- traveling - to satisfy this need one gets for example: bicycle, car.

2. Relatedness needs:

- sports games - to satisfy this need one gets for example: volleyball, renting a tennis court, white water rafting,
- spending time with peers - to satisfy this need one gets for example: party entrances, dinners in restaurants, computer, gaming devices,
- spending time with own children - to satisfy this need one gets for example: toy building brick, dolls, puzzles, card games.

3. Growth needs:

- acquiring knowledge - to satisfy this need one gets for example: books, courses, Internet connection,
- developing artistic talents - to satisfy this need one gets for example: extracurricular classes, musical instrument, painting set,
- developing local identity - to satisfy this need one gets for example: museum entrances, books, participation in local events.

Below placed is an illustration of the needs vector.

$$V_C = \begin{bmatrix} & & & & \dots & & & & & \\ bread & pork & \dots & water & \dots & volleyball & \dots & books & \dots & \\ & & & & \dots & & & & & \\ needs\ of : & & & existence & | & relatedness & | & growth & & \end{bmatrix}$$

For the sake of simplicity, presented vector contains only a few chosen needs and even less products or services that satisfy them. The following step would be to fill this vector with information about the maximum level of consumption for one individual. Next, taken into account should be restrictions named before.

Above described were steps taken in order to proceed with consumer needs modelling. Presented was an overview of the consumer needs vector, a basic element developed to describe individual's needs. In the following chapter human needs would be discussed in the context of the space of consumers with assigned needs vectors. Moreover, described would be the space of products containing goods used to satisfy various needs.

4 Structuring

Up-to-date models of consumers' needs have linear structures. In this section we attempt to open discussion on a nonlinear model of consumers' needs. We propose to describe consumers with vectors of goods and services they may need. In the subsequent sections we describe the space of goods and services in a form of a vector of amounts. Then we introduce description of a consumer as the vector of the same form as the vector describing the space of goods and services. The difference between both descriptions lays in interpretation of elements of both vectors. In the first case, we have amounts of available goods/services. In the second case, we have needs of given consumers.

4.1 The Space of Goods

In general, the space of goods is identified as all goods and services offered at the market as well as goods and services that are not available at the market, but are aware by consumers. Food, communication tools, cultural events are examples of available goods and services while a trip to the Mars is aware by people, but not available yet, hence its supply equals 0. All goods and services available and imagined during a given period, e.g. in a given year, are represented in the form of vector:

$$X = (x_1, x_2, \dots, x_N)$$

where the element x_i corresponds to the i th good or service. The element x_i is the set of units, if units of i th good/service are indistinguishable. For instance, cartons of milk, loafs of bread and cars of the same type and make are indistinguishable. The element x_i is the vector of all distinguishable units of given good or service. Concertos in the Opera House in the opera season, rooms in a given hotel and flights of a given airline are distinguishable (individual) units. Note that

distinguishable units can still be sets or vectors of elements. For instance, seats in the concert hall are enumerated and distinguishable while tickets without reservation for a given train trip are indistinguishable. Any product or service with distinguishable units may be decomposed to the vector of these units. So then, we may treat elements of the vector X of goods as single things or sets of indistinguishable things. We can also join similar entities in more complex vector/set structures. Formal conversions between both interpretations of the vector X are trivial and we do not attempt to discuss them. On the other hand, relations and dependencies between goods and services described by simple elements of the vector X are very important subject of research and practice in real economic, social and other environments. We plan to focus attention on these subjects in future research.

4.2 The Space of Consumers

Our very basic consumer's model is compatible with the vector of goods and services. We describe a consumer C as the the vector:

$$X_C = (x_{C,1}, x_{C,2}, \dots, x_{C,N})$$

with elements corresponding to elements of the vector X of goods/services. The value of a given element $x_{C,i}$ is amount of good/service he/she may need. In the first, basic, endeavor we assume that values of the vector X_C are limited only by consumer's needs. Any other restrictions, as - for instance - supply of goods/services or consumer's finance ability, are not considered now. So then, the consumer's description is based on biological necessities as well as on his/her personality rather than real behavior in the real world.

Future research will consider different restrictions put on consumers' needs such as mentioned above supply and consumer's finance ability but also price and taste and liking, luxuries and substitutes, religious and social groupings, age and sex, real necessities and marketing etc. Our goal is in creating a model of consumers and their needs which will describe economical processes better than the trivial model with no limitations.

4.3 Structuring

The above consumer's model is theoretically simple and clear. However, individual description of consumers leads dimensionality of the space to be huge, what makes practical analysis impossible. For that reason, the consumer's space must be structured in a way more useful in practice.

The fundamental operation in the space of goods/services and the space of consumers is comparison. Comparing two entities may lead either to equality or similarity, or to inequality in terms of smaller or greater, or to incomparability.

4.3.1 Indistinguishability

First of all we will be looking for groups of equal or similar entities in both spaces. Similarities will allow for reduction of dimensionality of the spaces. In other words, we will be looking for a relation, which will decide about indistinguishability or - at least - some kind of similarity of entities.

The well known equivalence relation is the very basic relation outlining indistinguishability of entities with regard to given attributes. Let us recall that the equivalence relation defined in the set X is a subset $\rho \subset X \times X$ of the Cartesian product $X \times X$, which is:

- reflexive, i.e. $(\forall x \in X) x\rho x$,
- symmetric, i.e. $(\forall x, y \in X) x\rho y \Rightarrow y\rho x$,
- transitive, i.e. $(\forall x, y, z \in X) x\rho y \text{ and } y\rho z \Rightarrow x\rho z$,

The equivalence relation create equivalence classes, i.e. defines sets of indistinguishable elements. Let us recall that a subset $A \in X$ is an equivalence class of the equivalence relation ρ if and only if:

- $(\forall x, y \in A) x\rho y$,
- $(\forall x \in A)(\forall y \notin A) \sim x\rho y$,

The notion of equivalence classes is fundamental one in formal modelling of indistinguishability.

So then, we define the relation $=$ assuming that two consumers are related if and only if vectors describing them are equal. Obviously, equality of vectors is defined as equality of all corresponding elements of compared vectors. If compared elements are structures (sets or sequences), then equality of these elements are understood as equality of both structures. The relation $=$ is, obviously, the equivalence relation, which creates its equivalence classes. As the result, we turn to analyze the set $X|_{=}$ of equivalence classes of consumers instead the set X of individual consumers.

4.3.2 Similarity

The relation introduced above may reduce dimensionality of the space of consumers assuming that there are groups of consumers being described with exactly the same vectors V_C . However, it seems that this assumption is too restrictive in modelling the real world and especially in modelling economic process. Moreover, the equivalence relation is defined based on crisp data, which is rather rare in economics. Therefore we will be applying less restrictive tools to define similarities, which will be involving imperfect data used in comparison of entities. Such tools should also define concepts of similar elements analogous to equivalence classes notions. Several concepts of similarity and indistinguishability based on imperfect data have been invented and studied, e.g. [2, 6, 8, 9, 11, 12]. Application of them as well as other concepts in consumers' space structuring requires careful investigations from both theoretical and practical perspective. The mentioned here concepts, solely based on fuzzy sets theory, and other need adaptation to the specific domain of economic processes. Of course, some analogue of equivalence classes should be created in order to reduce dimensionality of the problem.

Besides mentioned above methods of imperfect information processing, we plan to apply and investigate methods of clustering as similarity grouping. This powerful tool is used as very effective tool applicable in grouping similar units in many domains and practical applications. Different methods of clustering seem to be completely suited tools in our research. They should create classes of similar consumers, which are disjoint and cover the space of consumers. In this way we come to definition of an equivalence relation on the space of consumers. In consequence, we will come to indistinguishability feature of consumers.

Let us note that in both cases, a structure created with a similarity relation and the space $X|_{\equiv}$ will be represented as vectors with elements being equivalence classes or analogs of a similarity relation. So then, we get significant reduction of dimensionality of the space of consumers.

4.3.3 Incrementality

We will be questing for elements or groups of elements creating pairs or sequences of incremental entities. Inequalities, strict or not strict, are the fundamental comparing relations in this sense. They order the space of comparable elements creating partial and linear orders.

In this point we intend to structure consumers' space X and the space $X|_{\equiv}$ of equivalence classes comparing them in the sense of incrementality. Linear and partial orders are fundamental structures of this type. Let us recall that the pair (X, \leq) , where X is a set and \leq is a inequality relation $\leq \in X \times X$, is the partial

order if and only if the inequality relation is:

- reflexive, i.e. $(\forall x \in X) x \leq x$,
- antisymmetric, i.e. $(\forall x, y \in X) x \leq y \text{ and } y \leq x \Rightarrow x = y$,
- transitive, i.e. $(\forall x, y, z \in X) x \leq y \text{ and } y \leq z \Rightarrow x \leq z$,

If the partial order is total, i.e.

- $(\forall x, y \in X) x \leq y \text{ or } y \leq x$,

then it is called linear order.

Let us observe that models of consumer's needs described in Section 2 are directly or indirectly based on the structure of total linear order. They are modelling important perspective views on the space of consumers and consumer's needs, though - obviously - do not pretend to describe fully and exactly the real world of consumers and goods/services spaces. Our perspective research directions include modelling consumers space with special aware focused on dependencies between individual consumers and indistinguishability/similarity classes of consumers. In our opinion, a partial order is important view on the space of consumers with indistinguishability/similarity classes perceived. Vectors of consumer's needs, as described in section 4.2, are not always comparable in terms of indistinguishability, similarity or incrementality. Therefore, structures of partial orders seem to be good modelling tools.

The remark about incomparability of consumers and consumer's needs is grounded on observation that - for instance - a group of consumers must avoid cereal food while other group of consumers like cereal food. Both groups may be included in the same class of consumers, when we consider elementary, existential needs as the whole. However, when more detailed view is perceived, we get incomparable vectors of consumer's needs.

However, like in case of indistinguishability and equivalence relation, partial and linear orderings involve crisp data and, as a result, they are of little usefulness in modelling real economic process and phenomena. Accordingly, we will be looking for less restrictive counterparts, which are tolerant to imperfect economic data of the real world.

5 Conclusions

The paper is a manifestation of our research directions rather than pure investigation of the real world. In the paper we provide a model of the space of

goods/needs. The model is grounded in structures of vectors and sets. Then it is applied in modelling consumer's needs. In the first, basic, endeavor we assume that values of available goods/services are limited only by consumer's needs. Any other restrictions, as - for instance - supply of goods/services or consumer's finance ability, are not considered. So then, the consumer's description is based on biological necessities as well as on his/her personality rather than real behavior in the real world. This assumption allows for structuring spaces from purely algebraical point of view. Structures of indistinguishabilities, similarities and orderings are expected to expand the classical models of consumer's needs.

Well recognized theoretical structures of our model of consumer's needs will then be used to interpret the world of economic reality. Modelling ability of different scale economies, explaining dependencies of economical processes on different factors as, for instance, supply and consumer's finance, price and taste and likings of consumers, luxuries and substitutes, religious and social groupings, age and sex, real necessities and marketing etc.

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The papers presented in this Volume 2 constitute a collection of contributions, both of a foundational and applied type, by both well-known experts and young researchers in various fields of broadly perceived intelligent systems.

It may be viewed as a result of fruitful discussions held during the Tenth International Workshop on Intuitionistic Fuzzy Sets and Generalized Nets (IWIFSGN-2011) organized in Warsaw on September 30, 2011 by the Systems Research Institute, Polish Academy of Sciences, in Warsaw, Poland, Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences in Sofia, Bulgaria, and WIT - Warsaw School of Information Technology in Warsaw, Poland, and co-organized by: the Matej Bel University, Banska Bystrica, Slovakia, Universidad Publica de Navarra, Pamplona, Spain, Universidade de Tras-Os-Montes e Alto Douro, Vila Real, Portugal, and the University of Westminster, Harrow, UK:

[Http://www.ibspan.waw.pl/ifs2011](http://www.ibspan.waw.pl/ifs2011)

The consecutive International Workshops on Intuitionistic Fuzzy Sets and Generalized Nets (IWIFSGNs) have been meant to provide a forum for the presentation of new results and for scientific discussion on new developments in foundations and applications of intuitionistic fuzzy sets and generalized nets pioneered by Professor Krassimir T. Atanassov. Other topics related to broadly perceived representation and processing of uncertain and imprecise information and intelligent systems have also been included. The Tenth International Workshop on Intuitionistic Fuzzy Sets and Generalized Nets (IWIFSGN-2011) is a continuation of this undertaking, and provides many new ideas and results in the areas concerned.

We hope that a collection of main contributions presented at the Workshop, completed with many papers by leading experts who have not been able to participate, will provide a source of much needed information on recent trends in the topics considered.

ISBN-13 9788389475411

