XLI Incontro di Studio del Ce.S.E.T.: 55-78

Gianfranco Brusa
Alessandra Armiraglio

Politecnico di Milano – DiAP
Dipartimento di Architettura e Pianificazione – Architecture and Planning Department
E-mail: *brusa@polimi.it*

Gentrification and models for real estate analysis

This research propose a deep analysis of Milanese real estate market, based on data supplied by three real estate organizations; gentrification appears in some neighborhoods, such as Tortona, Porta Genova, Bovisa, Isola Garibaldi: the latest is the subject of the final analysis, by surveying of physical and social state of the area. The survey takes place in two periods (2003 and 2009) to compare the evolution of gentrification. The results of surveys has been employed in a simulation by multi-agent system model, to foresee long term evolution of the phenomenon. These neighborhood micro-indicators allow to put in evidence actual trends, conditioning a local real estate market, which can translate themselves in phenomena such as gentrification. In present analysis, the employ of cellular automata models applied to a neighborhood in Milan (Isola Garibaldi) produced the dynamic simulation of gentrification trend during a very long time: the cyclical phenomenon (one loop holds a period of twenty – thirty years) appears sometimes during a theoretical time of 100 – 120 – 150 years. Simulation of long period scenarios by multi-agent systems and cellular automata provides estimator with powerful tool, without limits in implementing it, able to support him in appraisal judge. It stands also to reason that such a tool can sustain urban planning and related evaluation processes.

Key words: *real estate, multi agent system, cellular automata*

1. Preface

Pragmatism of estimative research, founded in its farthest origins[1], singled out a double level of survey and data and information gathering to face and solve the question of real estate market analysis. On the one hand: the immovable which has to be appraised, i.e. its intrinsic specific features. On the other hand: the environment in which the immovable is located, i.e. the aspects connected to the location (environmental, economic, social, commercial, etc.) conditioning its actual or future value.

Particularly sharp was, in 1671, the way undertaken by Alessandro Capra[2], architect and estimator from Cremona, who singled out four features able to act on real estate value in urban areas.

The value of a building, he said, depends on four variables: la sostanza e qualità della materia (quality and quantity of materials employed in construction), l'artificio della fabbrica (the skill in construct), le comodità (inner distribution and dwelling comfort), la qualità del sito (quality of the place, depending on the location, its agreeableness and the wholesome air). We can affirm that his thought was enlightened and far-seeing. Issues identified by Capra are still included, according

[1] Brusa, G., (2007). *Metodo e prassi estimativa.* Santarcangelo di Romagna. Maggioli.
[2] Capra, A., (1671). *Geometria famigliare et instruttione pratica.* Cremona. Zanni.

to different purposes of appraisal, among the variables involved in the structuring of value and, probably, in the formation of the price of a property. It is true that the complexity, currently detectable, not only on the real estate market, but on the whole socio-economic scenario, has led to a much more detailed view of the matter. Research and analysis in the evaluative field of a set of variables able to act significantly in the formation of value, and subsequently of the price, are now open. The same applies to processing tools of data associated with these variables. At least there are two main approaches: statistical tools (for example: multiparametric mathematical-statistical models[3]) and resources, belonging to the cognitive sciences, including neural networks[4], fuzzy logic, rough sets,...

Another frontier, on which we focus in the heart of this contribution, is detectable in the use of cellular automata. Of course, within the basic appraisal of the value of property, traditional methods based on the simple direct comparison between the subject of the appraisal and homogeneous properties now are only partially able to grasp all the aspects that a changing market - and ever more sensitive to qualitative variables - poses to the evaluator.

The quality factor, not only objective but also subjective-perceived, can open interesting ways of research. It is not necessary to consider the objective dimension of a phenomenon, but it's indispensable, in increasingly complex situations of market and life, to deal with the subjective perception that individuals have of the condition in which they live and dwell and which shape the market in an even more relevant way. This means to bring the point of view of the analysis from the more traditional level of quantity (based on classical indicators: surface, floor, age, ...) or of the standardizable/directly quantifiable quality (proximity to services, number of stores, square meters of greenery per capita,...) to the scale of the quality perceived by the "user-consumer" and based on the changing and dynamic evolution of the needs and of individual and collective values. From the object perspective to the perspective of the subject "user / consumer". This does not mean to exclude the traditional "strong" approaches that always Estimate evokes and analyzes and that leads to the appraisal of the real estate, but it means to extend the investigation to additional complementary aspects, which can help to predict the dynamics of the real estate market besides motivating, in part, the current trend and supporting evaluations. Certainly the passage is not easy, but research continues to evolve and the tools to experience such an approach exist.

The analysis of phenomenons and dynamics of real estate market traditionally established on consolidate macro-indicators:

- The quantity of normalized transactions;
- The gross annual rents of real estate;

---

[3] Rosasco, P., (2002). "Le metodologie pluriparametriche nelle valutazioni immobiliari: un'applicazione al mercato genovese". *Quaderno Ce.S.E.T.*. 7. pp. 35-36.

[4] De Mare, G., (2002). "Un modello neurale per l'adeguamento dei campioni estimativi "scarsi" definito per la selezione dei canoni di locazione da banche-dati". *Quaderno Ce.S.E.T.*. 8. pp. 381-401.

- The per cent nominal variations of sale prices;
- The tenancy rents trend;
- The gap between supply and final sale prices;
- The mortgage loan rate trend;
- ...and so on.

These parameters allow to confirm past or present scenarios or, using appropriate econometric tools, to forecast situations in short time.

But the complexity of urban areas, of their socio-economic as well as physical evolution, of the consumer decision-making mechanisms also in view of real estate investment and of evolving lifestyles pose the need to investigate and socio-territorial and economic phenomena, related or connected in various ways to the real estate market, using models related to discrete dynamical systems, where a state of the system is determined by the previous state and its evolution is therefore attributable to an iterative process. I.e., going beyond the static view of phenomena conditioning the housing market, that mainly crystallizes the outlines in a sort of "here and now" space-time, only partially helpful to show future scenarios, anyhow limited to short terms.

In the case-study described here (which I followed, but the operating merit on which it must be recognized to the invaluable collaboration of Dr. Alessandra Armiraglio) the variables used are:

- the physical condition of buildings;
- year of construction;
- the years have passed since any renovation, conservation or maintenance;
- the kind of activities and the year of their launch;
- replacement of the population;
- the title of enjoyment of property;
- income users;
- their geographical origin;
- changes in ownership.

In addition to these quantitative indicators, subjecting a survey sample to a specific questionnaire, has been reached the emergence of qualitative indicators, able to reveal assessments and judgments about the quality of life and perception of issues, positive or negative , typical of the scope of investigation. The use of such micro-indicators, specific to a neighborhood or a circumscribed urban area, permits to bring out the trends that affect the local property market and can result in the initiation of phenomena such as gentrification. In the case of gentrification occurred in the district named Isola, in Milan, the use of discrete models, applied through the use of cellular automata, has encouraged, in a dynamic way, the construction of the likely trend of gentrification over a not limited period of time. The phenomenon of cyclical nature (of about twenty to thirty years), seems to recur several times, alternating with periods of decline and impoverishment, along a theoretical time axis of 100 – 120 – 150 years. Being able to construct scenarios which go beyond the few years of the projection obtained with traditional instru-

ments, can put in the hands of the estimator further arguments capable of supporting the required evaluation. Not least, it seems evident it may be used in the field of spatial planning and evaluation processes associated with it.

2. The research

The research presented here focuses on the analysis of a territorial and social phenomenon, gentrification, defined in 1964 by the British sociologist Ruth Glass and theorized for the first time by the American geographer Neil Smith in 1979. This is a complex phenomenon, which consists in converting an urban area in a district for the middle class and restoring homes and repurposing the environment, resulting in increased property values and expulsion of socially weaker classes.

The analysis method employs new technologies for simulation of complex systems, in general hardly represented by "classic" analytical tools and therefore broken down into simple entities in mutual interaction, that reproduce the complexity from local rules of logical-decision: cellular automata, constructed, in this case, using a structure of object-oriented programming. The research examines a case study found on the territory of Milan. For this purpose, it was carried out a depth analysis of the real estate market in Milan on the basis of data from three real estate agencies (Fondazione CaRiPLo 1960-1991, Centro Studi Gabetti 1988-2002, Borsa Immobiliare di Milano 1993-2008), leading to consider some gentrified neighborhoods in Milan, such as Tortona - Porta Genova, Bovisa, Isola Garibaldi. The Isola Garibaldi district is the subject of the final analysis, occurred through the physical and social surveys carried out in two separate times (in 2003 and 2009), in order to make a comparison and to check possible course of gentrification, and completed from a simulation by a multi-agent system model, specifically developed to predict long-term evolution of the phenomenon.

The choice of the area

The area chosen as a field of experimentation, in competition with two other districts – Bovisa e Porta Genova –, is the Isola – Garibaldi neighborhood. The reason for the choice lies in the spontaneous nature of its renewal and in the mix of functions that characterizes it: in fact, while the revival of Bovisa is decisively determined by the imposing presence of the Polytechnic and while Porta Genova quickly turns into a highly specialized neighborhood of fashion, art and design, the Isola seems to ignore his destiny of "city of fashion", always advocated, to such a point that It refuses it and continues to live and renew itself because of endogenous energy produced by its traditional activities – for example, the Blue Note and the Frida – by the myriad of stores that still have a pre-mall old style, as the ironmonger's shop, that actually sells everything, craft workshops in carpentry, violin making, dyeing of leather, the manufacturer of drums, the cyclist who serves as a gathering place where men gather to discuss, the technical ser-

vice centers (electrical appliances, boilers, ...) and auto repair shops, familiar bars, intensely popular, and shops "for housewives" (grocers, butchers, bakers, ...). The district, industrial area in the past, then abandoned, condemned to physical and social deterioration, today even in liveliness reveals a perceptible renewal of real estate assets, which for some years now manifests characters of gentrification: influence at the neighborhood level for renovation, the surge in sales prices and rents, the replacement of population, the establishment of art galleries, fashion workshops, bars, restaurants and luxury shops, recording and acting studios. A method of studying the regeneration of the area is now presented, that uses as a tool for analysis the technology of cellular automata in multi-agent systems.

3. Cellular automata

The emergence of cellular automata goes back to the origins of digital computing. The development of the tool, since the 50s of the twentieth century, has seen the participation of numerous researchers, including: Alan Turing, John von Neumann, Arthur Burks. John Conway, John Conway, a Cambridge mathematician, proposed a game called "Life," which brought together all the information on the CA in a model that simulates the key elements of the replication as simply as possible. While "Life" is the most well-known CA, it is perhaps the least applicable to real-world configurations; however, it embodies all the fundamental principles on which an CA is based.

First, the CA is made up of four elements:

- cells;
- the state of the individual cell for each time unit;
- the state of adjacent cells (neighborhood), which must depend on the state of each cell considered;
- the rules of transition from one state to another.

Key-elements that define CA:

- the rules must be uniform;
- the rules must be applied to each cell, state and nearby;
- any change in state must be local.

This latter aspect has become important for the applicability of the CA.

The fact that there can be no action at a distance means that there is no predetermined global order for templates and forms that a CA can create. From the simplest automata is easy to show that the unpredictability of the behavior of complex global models derives directly from the application of such local rules; the property of unpredictability makes CA so interesting. Their simple logic that reduces all into discrete state, discrete space and discrete-time initially seems to impose excessive restrictions on the representation of the properties of the system, but anything that can be translated from a differential equation into a polynomial equation can be represented by CA. The most interesting feature of CA

is that they give equal weight to the importance of space, time and attributes of the system, thus imposing a form that is forcing researchers to work hard in the representation of any system in which the importance of one of these elements is emphasized over the others. The application of CA to urban systems, considered themselves as CA, dates back to the origins of this matter, to the first attempts to construct mathematical models of urban systems in the early '50s, when Hägerstrand used them in demographic studies on Swedish population. In the early 60s, CA were included in the computing models aimed at planning of infrastructure and land use. Chapin and colleagues, from North Carolina, articulated, in the modeling of the processes of land development, space-cell models, in which state changes were expected as a function of a number of factors that affect every cell, some of which include neighborhood effects (Chapin and Weiss, 1968), and Lathrop and Hamburg (1965) for the development of the western region of the State of New York proposed simulations produced by a method similar to that based on cells. Waldo Tobler initially proposed space-cell models for the development of the city of Detroit, but in 1974 he officially began to explore the way in which the CA could be applied to geographic systems, landing in his famous essay "Cellular geography," published in 1979. In Santa Barbara, in the '80s, Helen Couclelis, influenced by Tobler, carried on these assumptions, until at the end of the decade, applications began to bear fruit in new areas, such as computer graphics, fractals, chaos, complexity, which led to the kind of applications currently used. There are characteristic adaptations of CA to the representation of urban systems. One in particular involves their relationship with geographical information systems (GIS). At a early level, it is evident a clear and unmistakable parallel with the GIS, in which data are represented by two-dimensional series in the form of raster or grid or mesh of pixels. Many types of physical data were represented in this way and rather specific GIS systems have been designed (IDRISI, GRASS, etc.).

Also, especially but not exclusively, with raster systems, the idea of using data as a layout, as a substrate, representing the transactions in a map by pixels or cells placed on different layers, leads directly to the idea of algebraic map that binds to the structure of CA: in fact, the rules of every cellular automaton can be considered as an algebraic map.

In fact, it is simplistic to think of a dimensional reduction of the CA, which can take n-dimensional forms, where n tends to infinity, accordino to the computational capabilities of the hardware.

4. Object-oriented programming: the paradigm[5]

The object-oriented programming (OOP below, Object Oriented Programming) is an extremely powerful programming philosophy and closer to the programmer, which allows you to create programs that survive to the continuous

[5] http://it.wikipedia.org/wiki/ Object-oriented programming

evolution of the system in which they live, by separating the implemented via of modeling the problem. The use of these techniques makes it easier to write programs, bringing it closer to our way of solving problems: the world around us, in fact, consists of objects that have their own characteristics (behaviors) that interact by exchanging messages (as they called OOP). The object receiving the message behaves in a manner consistent with the actions related to the message. The object-oriented programming is a "programming paradigm" based on a developing methodology "top-down", that solves the problems starting with higher levels of abstraction, to come to more concrete problems related to implementation.

5. A discrete model for the study of regeneration of an urban area

A discrete model is offered, formalized in terms of its implementation in a multi-agent systems. To do this, a simulation platform for multi-agent systems, called Swarm, has been used, in which, in our case, agents, embodying the physical - social elements of urban sphere, come to life. The [empirical] data are supplied by a real situation, detected in two successive stages, of which we wanted to monitor the evolution. A sized part of the city is considered (a quarter - or part of district - composed of some blocks) to test for development through the emulation mechanisms involved in "neighborhood" range; it consists in the area identified by the Isola – Garibaldi district, in the city of Milan.

The methodology

The dynamic entities are summarized in three classes, each with its own intrinsic properties and rules - internal to each class and external, between a class and the other - that constitute their variables.

Classes are:

PROPERTY UNITS, divided into:

FLATS: includes flats belonging to the analyzed part of the city. They are in close relationship with users, who - by definition - use them, and with the environment, whose changes are determined by the physical state of the housing itself.

The characteristic variables of this class of agents are:

AGE of the unit: it does not affect any stage of the model; it is entered as data to determine the architectural nature of the considered sector of city. Buildings are subjected to a life cycle that takes place by stages, each of which is accompanied by some level of capitalized rent and a certain type of user (as observed). The life cycle may end with the demolition or start over - after reaching a certain point - due to a maintenance or recovery.

Dwellings are divided into:

- x - new (age < 10 years)
- y - recent (10 years < age < 30 years)
- z - old (age > 30 years)

STATE of the dwelling: describes the physical state of housing, which can be:
1 – poor
2 – sufficient
3 – average
4 – beautyful

State is tied to the passage of the increase or decrease in capitalized rent. This is not explicit in the model, but it is implied in housing and environmental qualification.

ACTIVITIES: means any housing unit with destination of use different from residence, then: commercial, industrial, artistic, industrial, public or private They are divided by gender, according to their influence on the type of environment
1 – unskilled
2 – normal
3 – qualifying
4 - gentrifying

USERS: they are the owners and tenants of housing; adds to them, in a particular case of the life cycle of housing (gentrification), the figure of the investor. Owners and tenants have a RANGE OF INCOME
1 – low
2 – medium
3 – high
4 - very high

and an ASSOCIATION (one or more) with the properties that belong to them. Assign an association with the housing technically facilitates the steps of the purchase, sale, abandonment by the tenant, etc.., because it serves to directly a user link owner with their housing and then to verify the choices that the owner will make on the property in question.

The relationships identified are:
- free housing = owner not occupier not landlord
- occupied housing = owner
- occupier rented housing = owner lessor, with the addition of the tenant.

ENVIRONMENT: consists of a set of housing, activities and users. It is classified according to the variable TYPE, which describes four physical and social environment:
1 - degraded: widespread criminality, many abandoned buildings, no services;
2 - popular: scarce or basic services, low quality buildings, some a little 'deteriorated;
3 - average: good service supplied, good condition of the buildings (though not new);
4 - luxury: new buildings, restored or well maintained, prestigious services.

This variable is determined by the contribution of four components (themselves, variables of other classes of agents):

STATE of housing: temporal distance between two changes in state of housing.
RANGE OF INCOME of users of housing.
GENDER OF ACTIVITY (commercial, professional, tertiary, ...) in the area.

Of the values of each variable, arithmetic mean is calculated, and finally we get the arithmetic mean of the results obtained for each variable, considering that all variables have the same weight in defining the type of environment.

Logical steps - operational structure

The multi-agent system consists of a model - based on a main loop, in which agents move according to their functions and functions of the main loop - and an observer. The main loop is carried into the period of one year. Initially it brings to date the conditions for agents of the model: change or confirmation of the income range of users (with the help of a matrix that expresses the probability for each user belonging to a certain band, to improve or worsen their condition), the physical state of housing, the kind of activities; all housing units suffer the aging of one year. Then, for every type of user are carried out their actions: the tenant may leave the property or buy it to live in, the owner can perform routine or emergency maintenance, to occupy a unit of his own, to sell it to another user (internal or external the model), to rent the property to a tenant, to leave the property.

All decisions of users depend on the physical state of the housing and their income range, the environment is assigned a weight that increases or reduces the likelihood that the user acts: the type 4 (deluxe) is assigned a weight equal to 1.80%, type 3 (average) weight of 1.60%, type 2 (popular) and a value of 0.99% for type 1 (degraded) 0.75%.

So for every housing unit shall ensure the possibility to occur an event of gentrification, by will of an investor, resulting in the sale or lease of the property.

Finally, the kind of environment is calculated.

In the modules that compose the main loop are declined individual actions carried out or sustained by the different agents:

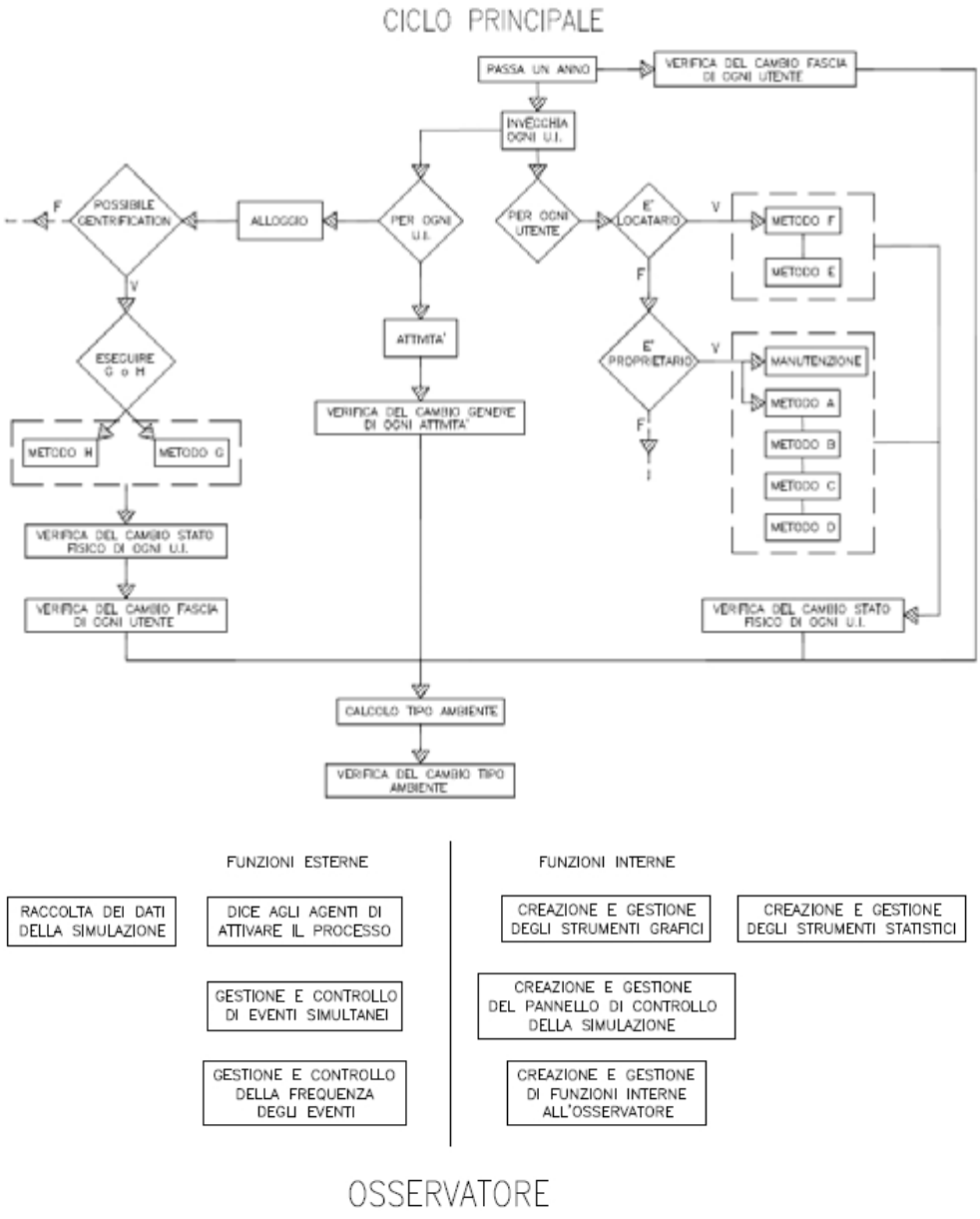
- The owner may decide to conduct on their property ordinary or extraordinary maintenance work; such a decision is determined by many factors:
  1. Relationship between owner and property, which a multiplier gives a weight, that will be greater if the owner resides in the property, intermediate if the housing is free (it can take over the decision to live in it, rent it or sell it) and less if it is occupied by a tenant, to whom is left the task of maintaining it or solicit the owner to do maintenance.
  2. State of Environment: an owner typically operates on his property to the extent that the surrounding environment calls to do so.
  3. Finally, the usual 4x4 matrix occurs (different for ordinary and extraordinary maintenance), which provides a probability based on the income range of the owner and the physical condition of the property.

  Routine maintenance does not change the physical state of the property, but it resets the year counter since the last reset status change, thus retaining the

physical condition; however, extraordinary maintenance, other than to reset the time from last physical transformation, raises the to next level the state of the property. The choice between ordinary and extraordinary maintenance therefore depends on the combination of the mentioned factors.

- In addition, the owner and the tenant have the right to make the following decisions:
  1. the owner occupies the housing; if there is a tenant, he leaves the housing.
  2. The owner sells the property unit; if a tenant remains, he is associated with the property, then 'solded' with it. The new owner (not an investor, do not buy to speculate) is characterized by a band of income calculated according to the physical housing, the type of environment and an element of randomness included in the evaluation of the band. The sale takes place as follows: the model checks if within the environment in which the simulation takes place there is a buyer for the apartment concerned. If no internal user is interested in buying the model is targeted to a buyer outside.
  3. The new owner is related with the housing as no occupant. To determine the income range of the owner, you need an 4x4 table, in which the physical state of the property and the kind of environment are associated. It is subject the attribution of a weight, obtained by extracting a random number that varies the income range, obtained from the table, as follows:
     if the number is between 0 and 0.15 and the income range of the table is greater than the level 1 (low), the income range decreases; if the number is between 0.86 and 1 and the range of income table is less than level 4 (highest), income range is increased; if the random value obtained is between 0.16 and 0.85, we accept the income range of the table.
  4. The owner decides to rent his property. If it is an occupier - owner, first leaves the housing, then leases it. A new user - tenant is created, whose range is determined by a 1x4 multiplier. It is a matrix of the probability that the state of the environment X would produce the band of income Y.
  5. The owner decides to vacate the property. If the housing unit is occupied by the owner, he free. If there is a tenant is evicted. The decision of the owner to release is governed by a 4x4 matrix, in which the probability that the event happens is related to the physical state of the property and to the income range of the owner.
  6. The tenant leaves the housing. The decisions of the lessee are subject to a 4x4 matrix of probabilities, determined by the physical state of the housing and by the income range of the tenant.
  7. The tenant purchase housing for live in: the former owner loses his relationship with the property, the tenant is then converted into owner occupier. This decision too is subjected to a probability matrix, similar to the previous one.
  8. If the housing unit has a physical condition level 'sufficient' or 'poor', and the kind of environment is 'popular' or 'degraded', we have the conditions for an intervention of gentrification. The combinations between the physical state of the property and the type of environment gives rise to a 2x2 table of probabilities.

Figure 0. The model structure.



In the case of gentrification, an investor, considered external to the model, bought the property. If there is a tenant is evicted, the former owner loses this property. If you do not have other, is removed from the model. The investor makes a routine maintenance from which gets a property characterized by a first level (beautiful) physical state: hence, the counter resets the years since the last change of physical state of the property. So the model creates a highrange new owner, who initially does not occupy and does not lease the housing. Besides users, buildings also have methods independent of the presence of users, because they depend on their nature: it is the change gender activities and the aging of the property. The method of "aging" takes place as follows: for each property is increased of a unit the number of years elapsed since the last change of physical state. Hence, the calculated time since the last change of state is compared with a 1x4 vector: it was assumed that the transition from the physical state 'beautyful' to the 'average' one has to spend 5 years without maintenance; the state pass from the average level to sufficient in 15 years; from sufficient to poor in 20 years and from poor to the elimination of the property from the model 30 years elapse. If the number of years elapsed between a change of state and the other is equal to one between just mentioned values of a vector, the step of property aging takes place (will be downgraded, unless it already belongs to the poor level) and years since the last change of the counter is reset. The method "changes such activities" relies instead on two 4x4 matrices of probabilities, where the rows are formed by such activities and columns from the average level of income obtained from groups of owners and landlords in the area. A matrix, the assignment of weights to certain combinations range + kind, such activities will determine the exchange rate down (% down), the other matrix, the assignment of weights to the other end + combinations usually result in a change activities generally upward (% up). As usual, we extract a random number for comparison with the percentage probability obtained for this case: if the number is less than% down and the kind of activity is different from the unskilled level, the activity is decreased, if the % of the number is greater, and the kind of activity is different from the level gentrificante, the task is promoted to the next level. If the number of years elapsed between a change of state and the other is equal to one of the values in the vector just mentioned, you shoot the aging of the property (it will be downgraded, unless it already belongs to the poor level) and years since the last change of the counter is reset. The method "changes activity gender" relies instead on two 4x4 matrices of probabilities, where the rows are formed by gender activity and columns by the average level of income obtained from ranges of owners and landlords in the area. A matrix, assigning weights to certain combinations of "range + gender" will determine the shift down of activity gender (down%). the other matrix, assigning weights to combinations of other "range + gender" gender activity will determine the shift down of activity gender upwards (%up).

As usual, we extract a random number for comparison with the percentage of probability obtained for this case: if the number is less than % down and gender of activity is different from the unskilled level, the activity is decreased; if the he number is greater than %up and gender of activity is different from the level gentrificante, the activity is promoted to next level.

Survey and use of materials and data

In the area of interest has been made survey of the aspects of model categories. The observation was made at two different times, in 2003 and 2009; although gentrification takes place over a longer time - usually in two decades - in the six years it has been possible to appreciate significantly the transformation in progress. In particular, the annotations are:

- the physical state of buildings, the year of construction, the years have passed since any renovation or maintenance;
- gender of activity and year (approximate) of their opening;
- the replacement of the population, the title of enjoyment of property, the income of users, their geographical origin, changes in ownership.

The physical state of buildings and gender of activity were examined directly and documented with photographic repertoire, while the news about the year of construction of buildings, maintenance or renovation, replacement of the population, title of enjoyment (property - hiring) of ui, and any income origin the users were drawn from questionnaires and direct questions addressed to residents of the district, demographic data collected by the Statistics Section of the City of Milan, from interviews with condominial administrators (which can be traced back through the tags displayed at the entrance of each building), from the survey of doorphones of buildings, yard signs and real estate listings. The questionnaire has also affected the issue of quality of life in the neighborhood and the perceptions of residents of the neighborhood and of its external users. among the 650 questionnaires distributed in 43 buildings, they were returned completed 408 (about 60% of people questioned); buildings were chosen according to their physical characteristics and to the features of residents (drawn from the doorphones, interviews to porters, to some residents or administrator). The questions and answers are below.

1) Da quanto tempo risiede in questo alloggio?
   a) da meno di 5 anni 23%
   b) da un periodo compreso tra i 5 e i 10 anni 55%
   c) da più di 10 anni 22%
2) Se prima di questo alloggio ne ha abitati altri, qual è stata l'ultima zona di provenienza?
   a) la stessa attuale 8%
   b) un'altra zona di Milano (indicare quale) ……
   c) un Comune diverso da Milano (indicare quale) ……..
3) Perché ha scelto di vivere in questa zona?
   a) l'acquisto dell'alloggio è stato conveniente 3%
   b) la zona è sembrata gradevole e ben vivibile 88%
   c) altro motivo (indicare quale) ……...
4) Di quanti locali è composto l'alloggio?
   a) da 1 o 2 locali 43%
   b) da 3 locali 45%
   c) da 4 o più locali 12%
5) Con quale titolo risiede nel suo alloggio?
   a) proprietario 70%
   b) affittuario 27%

c) altro titolo 0

6) Se è proprietario, come è entrato in possesso dell'alloggio?
   a) eredità o dono 9%
   b) acquisto 91%
   c) altro 0%
7) Se fosse venduto oggi, di quanto pensa sia aumentato il valore rispetto a quello del momento di acquisizione da parte sua?
   a) lo stesso valore o poco più 2%
   b) il doppio o quasi 8%
   c) più del doppio 90%
8) Se è affittuario, qual è la cadenza delle rate d'affitto?
   a) mensile 85%
   b) semestrale 13%
   c) annuale 2%
9) Qual è l'importo di una rata del canone d'affitto? ……..
10) Quanto era 5 anni fa? ……...
11) Se ha subito un aumento, quale può esserne la causa principale?
   a) rinnovo dell'edificio o dell'alloggio 73%
   b) rincaro dei prezzi in questa zona 49%
   c) rincaro della vita in città
12) Prevede di cambiare casa prossimamente?
   Sì 4%
   No 96%
13) Se sì, per quale motivo?
   a) per un alloggio più grande 3%
   b) per un alloggio più piccolo 0
   c) per un alloggio meno costoso 7%
   d) altri motivi 1%
14) Quale sarà (o potrebbe essere) la zona di destinazione futura?
   a) la stessa attuale
   b) un'altra zona di Milano (indicare quale) ……
   c) un Comune diverso da Milano (indicare quale) ……... 1%
15) Qual è la composizione del vostro nucleo familiare?
   a) famiglia con minori 38%
   b) un adulto con minori 2%
   c) coppia di adulti 30%
   d) single 12%
   e) coppia di anziani 14%
   f) anziano solo 4%
16) Qual è l'età del capofamiglia (o dell'unico componente)?
   a) 18-25 anni 1%
   b) 25-30 anni 25%
   c) 30-40 anni 35%
   d) 40-50 anni 13%
   e) 50-60 anni 12%
   f) 60-70 anni 11%
   g) oltre 70 anni 3%
17) Qual è la professione del capofamiglia?
   a) operaio 10%
   b) impiegato 13%
   c) dirigente 38%
   d) imprenditore 7%
   e) artigiano 6%

f) disoccupato 2%
g) studente 6%
h) pensionato 15%

L'EDIFICIO

18) Nell'edificio, quanti alloggi hanno cambiato proprietario o inquilini negli ultimi 10 anni?
a) nessuno 5%
b) meno di cinque 15%
c) più di cinque 80%

19) Nell'edificio ci sono alloggi rimasti non occupati per molto tempo?
Sì 0
No 98%

20) Negli ultimi 5 anni, nell'edificio, si è insediata una - o più - delle seguenti attività? (indicare quali)
a) studi professionali 73%
b) società 12%
c) laboratori artistici o artigianali 9%
d) studi di registrazione 1%
e) società di moda 5%
f) altro (indicare) …….. 0

21) Si ricorda quando l'edificio ha subito interventi di manutenzione?
a) da meno di 5 anni 34%
b) da un periodo compreso tra i 5 e i 10 anni 22%
c) da più di 10 anni 44%

IL QUARTIERE

22) Ritiene che il quartiere in cui risiede abbia subito delle trasformazioni negli ultimi 5 anni?
Sì 100%
No 0

23) Quali di queste attività hanno incrementato la presenza nel quartiere?
a) locali per degustazione X
b) ristoranti e negozi di prodotti etnici X
c) disco-bar, musica dal vivo X
d) osterie, trattorie X
e) laboratori artistici o artigianali X
f) laboratori teatrali X
g) studi di registrazione
h) società di moda X
i) gallerie d'arte X

24) Con quali aggettivi (uno o più) tra quelli qui sotto indicati definirebbe il quartiere?
a) sicuro
b) vivace X
c) familiare X
d) caotico
e) isolato
f) ricco X
g) non sicuro
h) 'spento'
i) ostile
j) vivibile X
k) molto frequentato dall'esterno
l) popolare X

25)	Ha notato un aumento delle seguenti attività?		
a)	ristrutturazione di edifici	Sì	No
		94%	0
b)	apertura di negozi "di lusso"	Sì	No
		35%	0
c)	apertura di locali "alla moda"	Sì	No
		90%	0
26)	Ritiene che la popolazione stia cambiando rispetto a qualche anno fa?		
	a) la popolazione residente appartiene a classi più elevate	100%	
	b) la popolazione residente appartiene a classi meno elevate	0	
	c) la popolazione di passaggio appartiene a classi più elevate	25%	
	d) la popolazione di passaggio appartiene a classi meno elevate	0	
	e) la popolazione che lavora qui appartiene a classi più elevate	39%	
f)	la popolazione che lavora qui appartiene a classi meno elevate	6%	

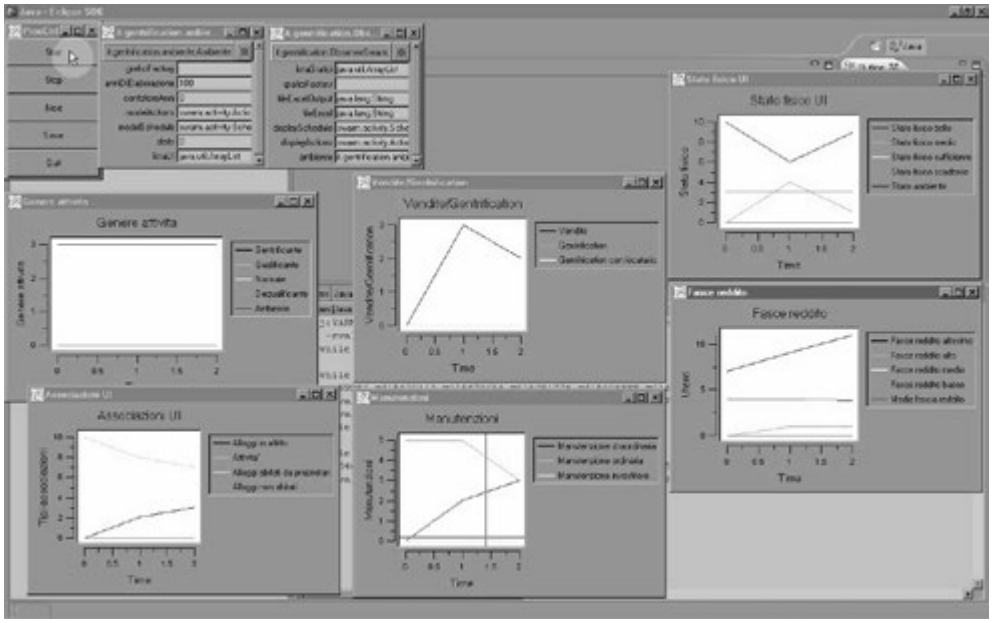
Answers put in evidence a clear transformation, as also confirmed by the people interviewed, but the neigborhood remains livable and familiar (replies 3 and 24 of questionnaire): the opening of new premises, the establishment of new businesses, the incipient replacing of population from lower to upper classes (responses 23, 25 and 26) did not affect the socio-environmental balance of residents and between residents and customers.

The field survey shows that the mix of functions exists, has not yet given way to a dominant function, as could happen in a few time with the opening of the City of Fashion. Up to now the reaction has taken place in the real estate market, with the significant rise in sales values and rents, the housing market typically responds well in advance to the transformation projects looming on urban land. From the first response to the questionnaire, the vast majority of the population has settled in the current home in the last decade (23% for less than five years and 55% for less than ten years) and from the answer 7, however, the price of apartment, if placed on the market at this time would be increased by more than twice the value paid by current inhabitants, a fact which is confirmed by the signs displayed in the real estate agencies and in the agencies of bodies of real estate values detection. The answers 15, 16 and 17 show the composition and income level of residents: the age of the householder or of the only component is for most cases between 25 and 40 years and the core is typically made up of families with children and pairs of adults (even of groups of adults, as observed), whose professions provide a medium-high income. Observing the physical state of buildings, it is confirmed the situation described from the answer 21: the renovation and new construction involving an actual "neighborhood effect", typical of gentrification: stand out streets Confalonieri, Cola Montano, Pastrengo, Dal Verme, Della Pergola, Borsieri, Minniti square, whose buildings were made object of ordinary maintenance work (painting of the walls) and extraordinary maintenance work (restructuring, including the individual units), where it is not even occurred a demolition and new construction of the building.

Implementation of the model

For the implementation of the model were coded the features of the agents of the model, ie buildings, business, owners, tenants, investors, as described below. The 43 buildings correspond to 1256 housing including 123 business shops, studios, companies, firms, laboratories, 1015 owners, 221 tenants, plus a variable number of investors. Parameters related to their characteristics (for physical buildings, construction year, years elapsed since the last change of state, for physical activity, year of construction and gender; for the owners the income group, the kind of association with the real estate unit, the list of properties; for tenants the income group and the association with the dwelling; for investors the only income group, generally high or very high.The users so distinct were divided into Excel spreadsheets, giving a sheet to each type of agent. The file also contains a sheet of constant (1,2,3,4) which identify the features of agents and a sheet containing matrices, multipliers and vectors. The random component of the model is instead provided by Swarm. The model is implemented in Eclipse, a software environment that enables the execution of multi-agent platform Swarm. The simulation results are instantly visible in the experiment in many graphics windows as there are analyzed agents and each window shows a diagram of characteristics relating to the single class of agents. In addition, Eclipse produces a text file (log) which contains the single step into the time taken by each agent tested, translated into a number that represents the ordinate value shown in the graphs just mentioned. It's easy (so to speak) to follow the results of the log file parallel to the steps involved in programming code.

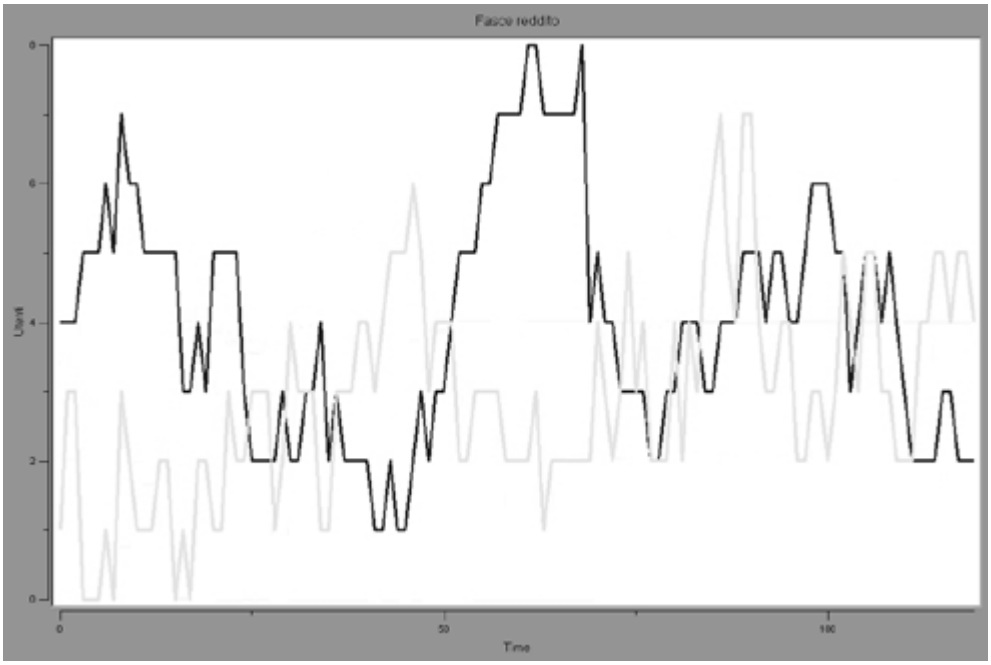
Figure 1. Eclipse boot console interface screen, Environment, Observer interface, and graphics.



Results and observations

To observe the development of the phenomena of gentrification in an abstract simulation requires a long period of observation, since a complete cycle of gentrification is taking place in about twenty - thirty years. Thus, several cycles of gentrification can take place over a period of theoretical 100 - 120 - 150 years. With the data of the current, real situation photographed with the reliefs on the field and with a set of parameters matrix referring to a condition of non-gentrification (the values of the parameters are, for example, "forced" to simulate an external intervention), by reading the graph the physical condition of buildings and the graph of the income level of the users, cycles of gentrification also emerge with a period of about twenty - thirty years (Figure 2). Please note that the activity of cellular automata does not depend on input data, as governed by random variables. By changing the initial conditions and forcing all the abandoned buildings, uninhabited and all owners with low income, you have a gentrification in the first 40 years, but later the situation stabilizes at intermediate values of users and revenues from real estate income (physical state real estate), although the model gets more attempts by investors in connection of which you see hints of gentrification in the sales graph; imposing instead the totality of beautiful buildings and owners, tenants, investors with high income group, it extends the life stages of gentrification and in an observation period of 150 years it has been only two cycles, among which is anyway a twenty-

Figure 2. Test 1: Diagram of income groups (high = blue; medium = yellow).



year phase of decline and impoverishment (Figure 3). in subsequent searches, the results would be generated directly on a space map, as it allows Swarm: identification number (ID) assigned to each agent, whether it be housing unit or user, can be attributed to a spatial unit on which it is automatically reported the result for the feature you decide to map. At the present state of things, although it can be traced back to a single ID, it is rather difficult to manually produce a map of the results, because the output file, in text, is made up of many thousands of information. In addition, you can change the model by varying the number and types of classes and agents and changing their features, making the simulation even more likely; gentrification is a complex phenomenon and linked to local factors, it is necessary that the means to represent it are totally flexible; a discrete model that accurately simulates reality detected may be ideally suited for this.

6. Conclusive remarks

The examination of an actual case of gentrification has allowed us to test, with the implementation of a rather simplified model the potential of cellular automata and multi-agent systems. The ability to simulate, using discrete models beyond the typical generalizations of the theorizations, with good approximation the existing reality and predict developments for the purposes of the study and control of

Figure 3. Test 3: Diagram of the physical state of the property units (blue = good; yellow = medium); the relative diagram of the income groups of users is very similar to this.

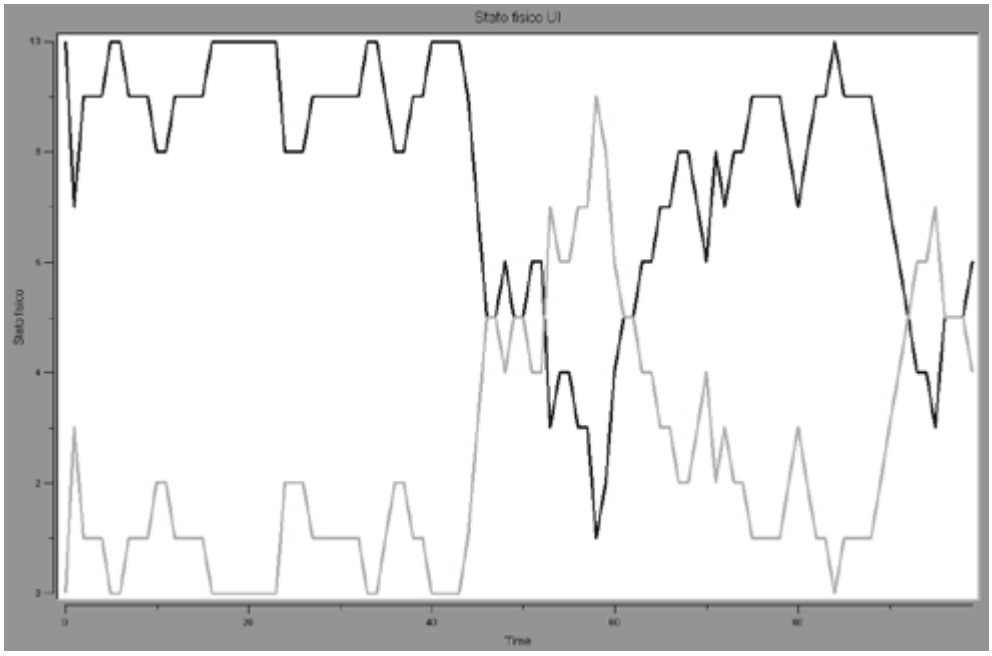


Figure 4. Comparison charts for the index "perceived urban quality" (zona Sant'Anna e zona Malpensata).

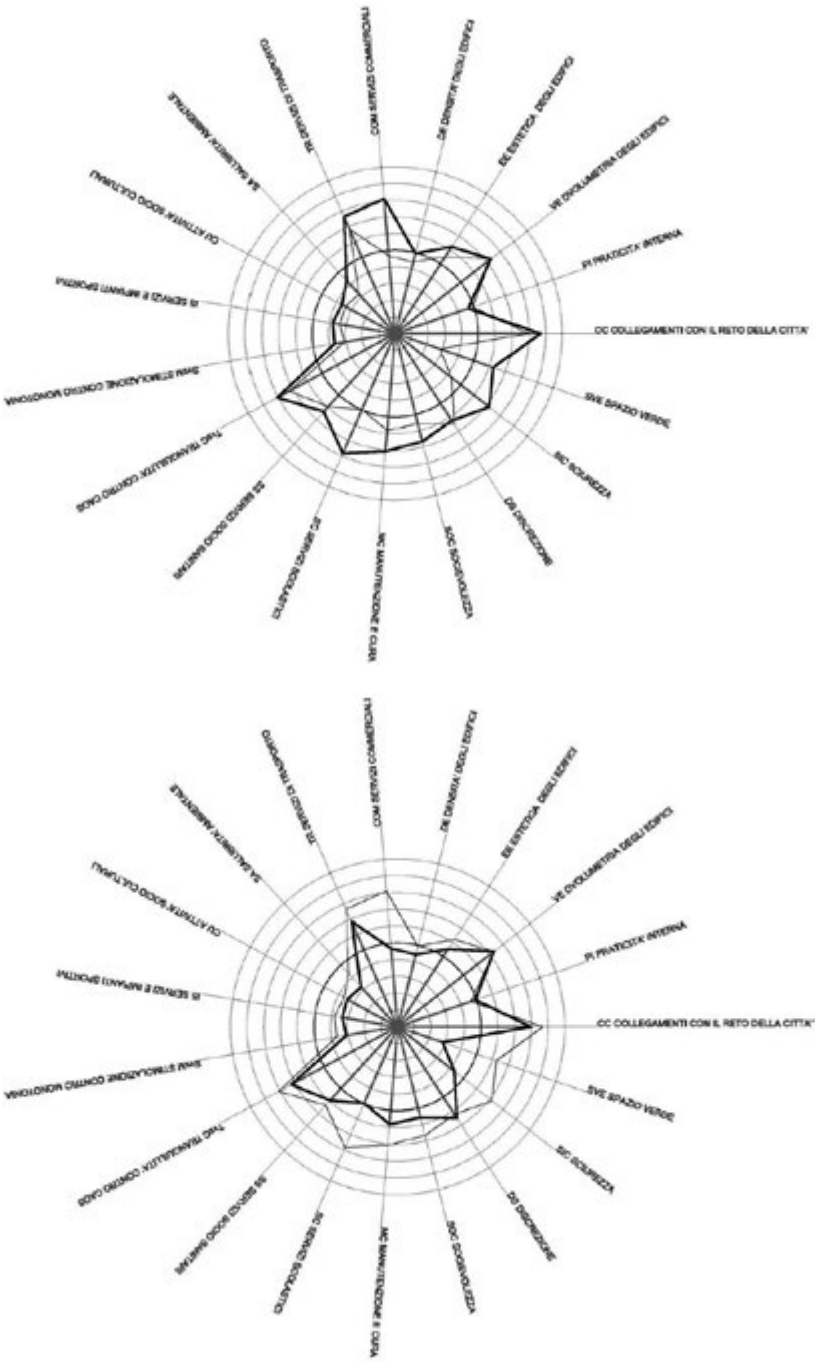
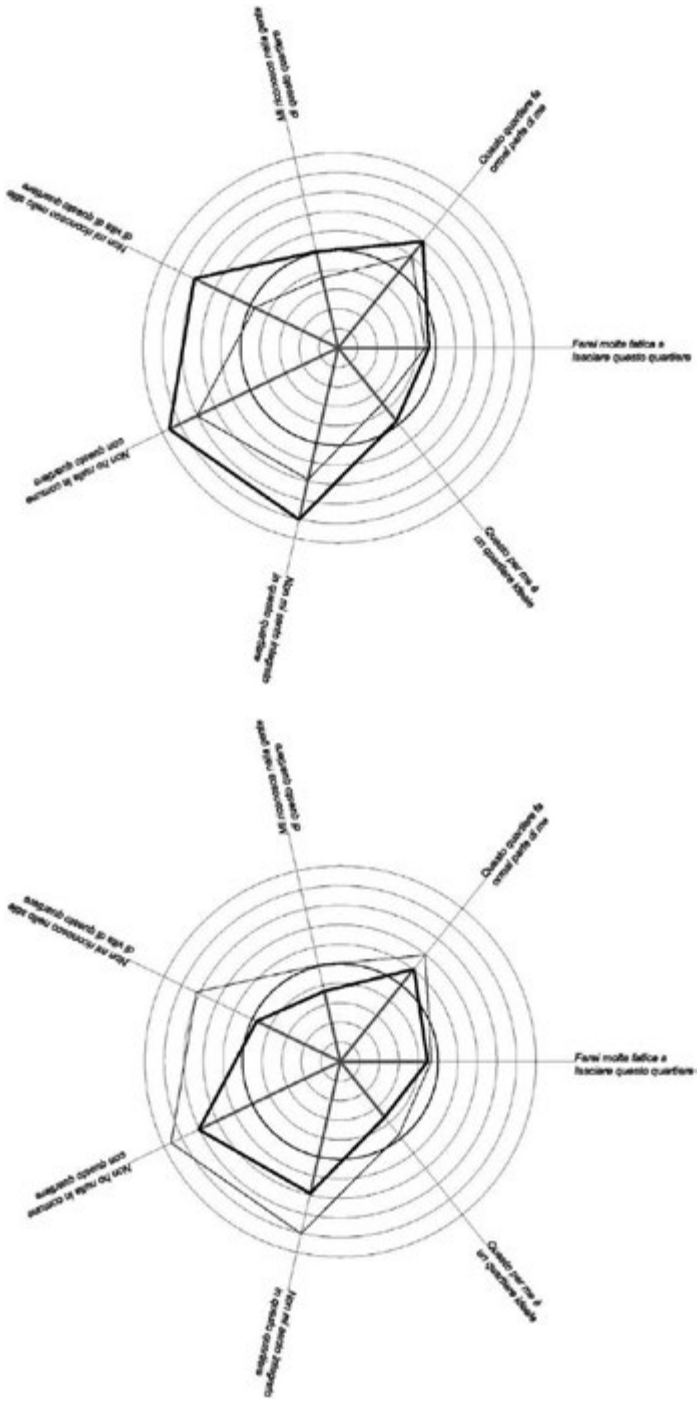


Figure 5. Comparison charts for the index "attachment to the neighborhood".



some spontaneous spatial phenomena of local, that affect the housing market and the structuring of the value and of real estate prices appears to be a "virtuous" way viable.

The innovative use of computer resources is an opportunity to exploit. The issues, from the traditional to the more recent emergence or broader that the discipline of estimates arises, can be faced with great care and sensitivity through the use of the new proposed instrument. Not only are the forecasts of real estate trends, based on historical data (prices, but also socio-economic indicators) have potential for development: complementary aspects of the evaluation issues including recalls the aforementioned issue of perceived quality, they can open scenarios and projections of interest.

The perception of quality in most urban areas, which covers psychological and sociological aspects, among others already dealt with according to the design process to architectural and urban scale (see the contributions of Marino Bonaiuto and altri), can become a field of testing and additional study in the Estimate. Surely there are difficulties, but it is important to be aware that the quality of life (and all the decisions and choices related to it) depends not only on objective reality, but increasingly on the subjective perception that we have of it. In other words, very banally exemplifying, I can have my house next to a large park, but its excellent preservation or its visible state of disrepair immediately change, in my opinion, the judgment (and the consequent attribution of value) that may result from that presence. The attention to multiple cognitive, affective and conative features related to the perception and evaluation of the quality of areas and of user satisfaction is, therefore, crucial for this type of evaluation approach. the effects of the perception of environmental quality on property values are evident in a study initiated by me (whose overall figures are still being processed and ultimately forthcoming) in some districts of Bergamo. Significant are the first findings in two parts of the city. similar Areas for use and physical features, but perceived by the population living in rather different ways. The comparison verifiable in the following figures, between the two areas with reference to two indices: "perceived urban quality" and "attachment to the neighborhood," seems to justify the current trend in real estate market.

In particular, comparing the data from both districts it can be seen that there are some indicators of urban residential quality perceived as matter of priority in carrying out such an emotional role, and similarly, the conditioning the local real estate market trends. Thus, for example, the perception in the neighborhood of a comfortable life style (aspect of context), the presence of accessible green areas (urban and architectural aspects) and satisfaction with neighborhood social relations (social and relational aspects) seem to represent the size that best predict a positive attachment to the district of residence.

The impact on the housing market, negative in the area Malpensata, are evident.

Price trend (zone Sant'Anna):		Appeal:	
2.66 %	- falling,	22.06% ⌂	low
94.21%	+ / - stationary	50.80% ⌂ ⌂	average
3.13%	+ rising.	20.14% ⌂ ⌂ ⌂	good
		0.00% ⌂ ⌂ ⌂ ⌂.	higher

Price trend (zone Malpensata):		Appeal :	
53,81%	- falling,	50,30% ⌂	low
46,19%	+ / - stationary	38,08% ⌂ ⌂	average
0,00%	+ rising.	11,62% ⌂ ⌂ ⌂	good
		0,00% ⌂ ⌂ ⌂ ⌂	higher

From the summary above, it can be stated as today, more than ever, the concepts of territory quality (not only real but also perceived) and value are increasingly strong connected each other.

Finally, it insists that the use of innovative tools and attention to issues, complementary to the traditional estimation matters, can give start to new fields of research within the discipline.

Bibliography

Batty M., Couclelis H., Eichen M. (1997). Urban systems as cellular automata. *Environment and Planning B: Planning and Design* n° 24 (2).

Bonaiuto M., Bonnes M. (1996). Multi-place analysis of the urban environment: a comparison between a large and a small Italian city. *Environment & Behavior*, 28, 699-747.

Bonaiuto M., Bonnes M. (2002). Residential satisfaction in the urban environment within the UNESCO-MAB Rome Project. In J.I. Aragonés, G. Francescato, T. Garling (eds.). *Residential Environments: Choice, Satisfaction, and Behavior.* Bergin & Garvey, Westport, Connecticut (pp. 101-133).

Bonaiuto M., Bonnes M., Continisio M. (2004). Neighborhood evaluation within a multi-place perspective on urban activities. *Environment & Behavior*, 36, 41-69.

Bonaiuto M., Carrus G., Martorella H., Bonnes M., (2002). Local identity processes and environmental attitudes in land use changes: The case of natural protected areas. *Journal of Economic Psychology*, 23, 631-653.

Bonaiuto M., Fornara F., Bonnes M. (2003). Indexes of perceived residential environment quality and neighbourhood attachment in urban environments: a confirmation study on the city of Rome. *Landscape and Urban Planning*, 65, 41-52.

Bonaiuto M., Fornara F., Bonnes M. (2005). Measures of perceived residential environment quality and neighbourhood attachment in middle- and low-extension cities. *European Review of Applied Psychology*, in press.

Bradford and Rubinowitz (1975). The urban-suburban investment-disinvestment process: consequences for older neighbourhoods. *Annals of the American Academy of Political and Social Science* n° 422.

Brusa G. (2007). *Metodo e prassi estimativa.* Santarcangelo di Romagna. Maggioli.

Brusa G., De Rada D. (a cura) (2010). *Atti del Convegno "Dinamiche territoriali, qualità urbana, investimenti e mercato immobiliare*, Santarcangelo di Romagna, Maggioli.

Burks A. W. (Ed.) (1970). *Essays on Cellular Automata*, University of Illinois Press, Urbana, IL.
Capra A. (1671). *Geometria famigliare et instruttione pratica*. Cremona. Zanni.
Chapin F.S., Weiss S.F. (1968). A probabilistic model for residential growth, *Transportation Research* n° 2.
Couclelis H. (1985). Cellular worlds: a framework for modelling micro-macro dynamics, *Environment and Planning A* n° 17.
Cybriwsky R. (1978). Social aspects of neighborhood change, *Annals of the Association of American Geographers* n° 68.
Daniels Marcus (October 1999). *Integrating Simulation Technologies with Swarm; Agent Simulation: Applications, Models and Tools.* Argonne National Laboratory, University of Chicago (paper).
Davis J.T. (1965). Middle class housing in the central city, *Economic Geography* n° 41, July.
De Mare G. (2002). Un modello neurale per l'adeguamento dei campioni estimativi "scarsi" definito per la selezione dei canoni di locazione da banche-dati. *Quaderno Ce.S.E.T.*. 8.
Gardner M. (1970). The fantastic combinations of John Conway's new solitaire game "Life", *Scientific American* n° 223.
Haegerstrand T. (1967). *Innovation, diffusion as a spatial process*, University of Chicago Press, Chicago, IL.
Holland J. (1975). *Adaptation in natural and artificial systems*, The University of Michigan Press, Ann Arbor, MI; reprinted and published in 1992 by MIT Press, Cambridge, MA.
NeXT (1993). *Object Oriented Programming and the Objective C Language*, NeXT Computer, 0-201-63251-9, 1993, Addison-Wesley. [This book is out of print, but availble at the Apple website]
Rosasco P. (2002). Le metodologie pluriparametriche nelle valutazioni immobiliari: un'applicazione al mercato genovese. *Quaderno Ce.S.E.T.*. 7.
Smith N. (1979). Gentrification and capital: theory, practice and ideology in *Society Hill, Antipode* n° 11.
Smith N. (1996). *The new urban frontier*, Routledge, London and New York.
Van der Linden (1994). *Expert C Programming: Deep C Secrets*, Peter van der Linden, 0-13-177429-8, 1994, SunSoft Press: Prentice Hall.
www.swarm.org, Copyright © 1999-2000 by Swarm Development Group (Santa Fe Institute e University of Kansas)
http://forum.ubuntu-it.org
http://java.html.it