XXXVI Ibero-Latin American Congress on Computational Methods in Engineering
CILAMCE
Rio de Janeiro, 22-25 Nov 2015

KNOWLEDGE DIFFUSION AND TRANSFERING IN A RESEARCH CHAIN: PATHS, RETENTION AND VELOCITY INFLUENCES

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Abstract. *The exponential flow of information and knowledge sources has a direct impact on human actions. Human knowledge generation, diffusion, absorption, together with brains migration, affects a nested complex of ours relations closely related to environment management, development changes, and technological evolution. Understand those problems need innovation, mainly in the context of comprehension of knowledge behavior processes. Our knowledge transferring computational model looks to the interactions between knowledge path chain and the velocity of the knowledge transferring, in a chain of research groups dealing and being affected by those phenomena. A partial difference system of equations solutions was allowed in a finite element semi-discrete modeling approached, for a numerical study of knowledge evolution process. This evolutionary model consider accumulation and feed-back of knowledge as also as the paths of knowledge transfer, in a transient two dimension domain as the researches chain of knowledge. A retention term, as a function of the mutual researches revenue phenomena, and convective terms were considered. Numeric experiments consider changes in scientific knowledge generation, diffusion coefficients, knowledge inductance, and retention terms, together with impedance function. We show that knowledge revenue of researches leaders is a result of knowledge flux interaction to the others researches and to the outside of the research chain, influenced by intertwined parameters on the connection of preferential diffusion paths.*

Keywords: *Knowledge diffusion and generation; knowledge chain preferential paths; knowledge transfer velocity; computational model*

1 INTRODUCTION

In the context of this work, preferential paths are ways or segments of the research chain (or region) where the flux of knowledge is favored by (i) the relations between researchers, or (ii) by the management of the research chain.

We explore the influence of preferential paths on the knowledge transferring behavior of a mutually linked and intertwined set of researches. Interaction between those ones occurs between neighbors in the research chain. In this sense the research chain is represented as a bidimensional domain, in which a point represents minimally a researcher. Some sub regions of this domain are put closed together by preferential paths in a more favorable interactive panorama.

The significant influence of preferential paths in research chains had been already pointed (Bevilacqua, Galeão, Pietrobon-Costa, Monteiro, 2010a). The substantial effect of convection in this behavior, meaning the brains migrations – or researchers change of professional positions between researches center - across and outside the research chain had already been investigated (Bevilacqua, Galeão, Pietrobon-Costa, Monteiro, 2010b). Now we group together those phenomena acting together with the retention process on the research chain.

That net of relations nesting individual researches or research groups belongs to a large amount of adjacent segments of a same society or possibly to the interaction process between different societies (Bevilacqua, 1980, 2001). Precedent papers (Cavalli-Sforza, et al., 1981, 1982, 1993) exposed ideas concerning to the quantification of knowledge transferring process, related to cultural transmission networks, inside and between social groups.

The continuum knowledge transfer model is based on a simple discrete approach which using a simple diffusive fundamental process defines a consistent constitutive law to knowledge interactions on a research chain, that allows to take into account the retention effects in the diffusion process (Bevilacqua, Galeão, Pietrobon-Costa, 2011a). Analytical formulation of the diffusive knowledge process with retention, developed and qualitatively analyzed before, shows that it belongs to the class of the second order partial differential equation, as in the classical diffusion approach, meanwhile it requires not only the classical second order diffusion term, but also a fourth order retention term, weighted by a knowledge transferring control factor, β. This retention term acts as a second order diffusivity, mirroring the knowledge researcher learning revenue (Bevilacqua, Galeão, Pietrobon-Costa, 2011b).

We consider that as ideas the behavior of this problem have been explored for about the last thirty years. Our target is the study of the influence of paths of preferential diffusion propagation, working together with knowledge diffusion, and knowledge retention – in the sense of revenue - at the knowledge chain. Knowledge generation by some detached segments – the most productive – of chain's researches is also taking in account. Those phenomena, as component of the proposed computational model, performs the net of relations between researches of the chain, evaluating the influence of the mutual transmission, diffusion and generation, of knowledge, together with the parameters that introduces those aspects in the problem and play main roles in those processes.

A general complete approach (Cavalli-Sforza, 1993; Feldmann et al., 1994, 1995) considers both genotype and phenotype factors to study the evolution of social groups. That is, inheritance and social interaction are both shaping the history of the group. As an analogy the phenomena take in account to the present knowledge transfer model is relative to inheritance, as knowledge retention is, and social interaction, as knowledge diffusion and brains migration are. Inductance and generation of knowledge are key aspects of social interaction in this related chain net.

We are interested here in a relatively short period of time, through interaction among groups or sub-groups, the horizontal aspect of the knowledge diffusion problem that constitutes the predominant panorama of the knowledge network behavior. In this way, some examples will be showed and analyzed, considering a two dimension domain that represents the research chain. In this domain, the diffusion, generation, retention, and transmission of knowledge occur between the researches of this net. The problem is considered full transient. The mathematical model incorporates a diffusion coefficient, a generation, and a knowledge inductance, or impedance, coefficients, and also the transferring coefficient, as the parameters that guide the dynamic behavior of knowledge in the research chain.

Results behavior denotes the influence of the connection and of the preferential diffusion paths, the determinant influence of brain migration, and the strong effect of boundary conditions on the knowledge chain evolution. In the section 2 the mathematical model is considered, together with an analysis of the physical meaning of the knowledge conditioning parameters. Section 3 contains the variational and finite element model, with considerations about the solution method. At section 4 some numerical examples are developed and comments are related to the computational solutions of the problem.

The approach adopted in this work is a step in the development of the study of the knowledge propagation in social groups. Other steps will be needed until a computational model concerning to the evaluation of innovation impact in human society could be operational. In this way retention terms, considered here, may be associated to individual cognitive process, allowing a more realistic knowledge dynamical model. In the future, correlation with experimental data is recommended to check the computational solutions, and contribute to the adjusting of the model, as most near as possible to the real behavior of the problem. This goal could allow the design of a model to target some grants and revenues in research support, as also the impact of innovations in human development.

2 MATHEMATICAL MODEL: A TRANSIENT DIFFUSION MODEL

The equation that guides the transient diffusive problem of knowledge transfer, with generation, reads:

$$c_p \frac{\partial u}{\partial t} + (\mathbf{v} \cdot \nabla) u + \beta(1-\beta)\, div\left(K_4 \nabla \Delta u\right) + \alpha C_0 u = \beta\, div\left(K_2 \nabla u\right) \qquad (1)$$

In eq. (1) we have: u(x,y,t) as the function of knowledge level, or knowledge density in time, of the researches or research groups of the chain net, being x,y the spatial coordinates and t the time one. In the model, c_p is the cognitive inductance, or what is the same, the cognitive impedance, meaning the incentive to acquire knowledge, K_2 being the diffusion coefficient, i.e, cognitive permeability, of the chain net, and its analogous diffusivity K_{path} being the diffusion coefficient into preferential paths link ways. A retention coefficient K_4 was adopted in the meaning of the individual research learning revenue. The parameter **v** answer to the velocity of brain migration in the research chain, and $r = \alpha C_0$ to be the coefficient of knowledge generation of the researches or research groups. In this approach, div (...) and ∇ (...) are respectively the divergence and gradient operators, restricted to the bi-dimensional chain domain, as considered. Into this domain, a subset of R^2, the researches or groups are distributed in an uniform density to this step of the model.

The analysis of the qualitative behavior of the chain, considers the relations and the influence of the cognitive impedance, diffusion and generation across the net. In the sense of development of a sensitivity analysis of the problem to the variation of those key parameters, we consider a non-uniform evaluation to c_p, K_2, K_4, K_{path}, and r. With this approach, those functions are defined as:

$$\begin{aligned} c_p &:= c_p(x, y) \\ K_2 &:= K_2(x, y) \\ K_4 &:= K_4(x, y) \\ K_{path} &:= K_{path}(x, y) \\ r &:= r(x, y) \end{aligned} \tag{2}$$

Those parameters have the following meaning:

K_2 and K_{path} : Cognitive Permeability. It controls the knowledge flow in the research chain, from the knowledge producers to others members of the chain. It depends of the net researches competence to transfer knowledge from one segment to another and the willingness of the individuals in the group to teach and learn. Increasing values of K_2 leads to increasing values of the knowledge flow across the chain.

K_4: Cognitive Retention. This parameter controls the knowledge flow to the knowledge producers of the research chain. It depends of the net researches competence to analyze, comprehend and incorporate the knowledge transferred from others researches to himself. As the K_2 parameter, this one relates one segment to another and the willingness of the individuals in the group to teach and learn. Increasing values of K_4 leads to increasing values of the growing of the knowledge level density across the chain.

C_0: Creativity. This parameter reflects the creativity inherent to the groups of individuals in the chain. It translates the amount of knowledge produced. The higher the value of C_0, the more creative will be the individuals in the group.

c_p: Cognitive impedance. This parameter expresses the velocity of knowledge absorption in the chain. The lower the value of C_p the faster will be the ability of individuals or groups to learn and master new knowledge. High values of C_p mean slow learning capacity. It is a kind of intellectual inertia or impedance, meaning not creativity. It is possible to have a creative person with relatively low ability to learn.

α: Investment or any other mechanism intended to enhance productivity. This parameter is related to the investments and incentives to maximize the output of each segment in the production chain.

Knowledge is, in this approach, analogous to a form of energy that flows along the chain. The difference in knowledge production between two segments generates knowledge flow in these segments. In a perfectly, hypothetic, homogeneous society where the knowledge production would be evenly distributed, no knowledge flow could occurs. The difference in knowledge learning revenue between neighbors at the chain generates a growth in the owned knowledge by the researches.

The knowledge level, u, in this model, is a continuous function that answers to the impact of the knowledge density, in the bi-dimensional domain. This function is also the measurement of the variation of knowledge in time at each cell of the knowledge network. In this sense a point or cell of this space may contains one or more than one researches, with it's own level of knowledge. Knowledge density at a section cell of the network net represents the characteristic knowledge level as result of the knowledge production, proper to each segment in the chain, affected by cognitive processes, ranging from scientific papers to hardware.

With this consideration, the flow is always in the opposite direction of increasing u(x,y,t). In other words the flow runs in the direction of decreasing potentials, from plus to minus. As a consequence there is no privileged flow direction regarding the nature of the output of the different groups in the chain. Therefore knowledge flow intensity is proportional to ∇u(x,y,t), to K_2(x,y), K_{path}(x,y), and K_4(x,y), is conditioned by c_p(x,y), and by the intensity of knowledge generation, r(x,y). Meanwhile K_2 is the proportionality factor of knowledge diffusion from one point to other of the knowledge network, except inside the preferential paths ways, where it corresponds to K_{path}(x,y); and K_4 the proportionality factor of the knowledge retention or retrofit is this nested network or chain.

3 VARIATIONAL AND FINITE ELEMENT FORMULATIONS

Let the knowledge transfer network domain be represented by $\Omega \subset R^2$, the bi-dimensional real space. This domain refers to a planar chain of interconnected research cells, as established before, where each one is connected to their neighborhood, meaning that there is interchange of knowledge only if exists connections between researches or groups of this social chain. So, even if restricted by a boundary, this medium consists of an infinity number of points, or cells, whole coupled by the diffusion and induction cognitive processes. Let we denote:

$$\begin{aligned} &u \in U = \{w(x,y,t) \in H^2(\Omega) \mid w = \overline{w} \ \ in \ \ \Gamma = \partial U\} \\ &\hat{u} \in U_0 = \{v(x,y,t) \in H_0^2(\Omega) \mid v = 0 \ \ in \ \ \Gamma = \partial U\} \end{aligned} \tag{3}$$

respectively the spaces of trial, u, and weight functions, $\hat{u}$, for a variational formulation of eq. (1), where $\overline{w}$ is a prescribed value in the boundary, Γ, of the domain.

An implicit formulation was adopted to deal with the solution of the diffusive problem with generation of knowledge. A Galerkin formulation was then developed to deal with the weak form of eq. (1). To develop a finite element formulation of the problem given by eq. (1), we also assume that U^h is the finite subspace counterparts of U. A mesh of finite elements was then adopted, to solve the problem in a finite numbers of points of the discrete network domain. At this point, the domain Ω was then discretized into a discrete number of finite elements. Defining a partition $P^h(\Omega)$ given by a limited number, *nelm*, of triangular elements on Ω, that are subdomains of the whole domain, such that the new discrete domain is given by:

$$\overline{\Omega} = \bigcup_{e=1}^{nelm} \Omega^e \tag{4}$$

Considering that, in eq. (4), each of the subdomains Ω^e has a smooth piecewise boundary, such that $\Gamma=\partial\Omega^e$, and "h" be the characteristic mesh size (Donea and Huerta, 2003).

The solution is given in each n^{th} time step, with respect to the $(n-1)^{th}$ of knowledge density, u, in the nodes of the mesh. Under these definitions the finite element semi-discrete formulation of the continuous problem (1), reads:

- For each $t \in [0,T_{max}[$, given $(\alpha, C_0, c_p, K_2, K_4)$, find $u^h \in U^h$, such that for $\forall \hat{u}^h \in U_0^h$:

$$\int_{\Omega^e} c_p \frac{(u^{h,n}\hat{u}^h - u^{h,n-1}\hat{u}^h)}{\Delta t} d\Omega^e + \int_{\Omega^e} \hat{u}^h (\mathbf{v}\cdot\nabla) u^{h,n} d\Omega^e + \int_{\Omega^e} \beta K_2 \nabla u^{h,n} \cdot \nabla \hat{u}^h d\Omega^e + \\ + \int_{\Omega^e} \beta(1-\beta) K_4 \nabla^2 u^{h,n} \cdot \nabla^2 \hat{u}^h d\Omega^e + \int_{\Omega^e} \alpha C_0 u^{h,n} d\Omega^e = \int_{\Gamma} \beta K_2 \hat{u}^h (\mathbf{n}\cdot\nabla u^{h,n}) d\Gamma + \\ + \int_{\Gamma} \beta(1-\beta) K_4 \nabla u^{h,n} \cdot \nabla \hat{u}^h d\Gamma \tag{5}$$

for:

$$\begin{aligned} &u^h = \bar{u} && on\ \Gamma \\ &u(x,y,0) = u_0 && in\ \overline{\Omega}\ \ at\ \ t=0 \end{aligned} \tag{6}$$

4 RESULTS AND COMMENTS

In previous works (Bevilacqua, Galeão, Pietrobon-Costa, Monteiro, 2010a and 2010b) we deal with the preferential paths effects, connecting groups of researchers in the knowledge chain, and with the influence of researchers migration along and to the outside of that network. Particularly results developed in those papers show that groups that has strong interactions and knowledge exchange with a more developed one, with relation to knowledge density, have a high growth performance in it's knowledge density level. Otherwise, the brain migrations tends to concentrate knowledge at specific regions of the knowledge chain while tends to damage the revenue performance of some knowledge chain.

Early results (Bevilacqua, Galeão, Pietrobon-Costa, Monteiro, 2010a) shows that in a low diffusive and also low generation profile, in presence of a relative high knowledge impedance, a closed in itself research chain evolves to a limited knowledge level and then stagnates. Figure 1 gives this result for a one dimensional chain, $c_p = 4$, and taken $K_2 = 1.2$ in whole domain, and knowledge generation, r, taken to be low, at 1.0 level.

Know, to evaluate the efficiency of the proposed computational model four numerical, as also to investigate the coupled effect between retention process, brain migration, and preferential paths, on the research network, four experiments were performed.

All of the experiments performed on those examples are given at an arbitrary adopted (10 x 10 unities) square domain, with an initial uniform condition of $u_0 = 4\text{-}\sin(\pi x).\sin(\pi y)$ in all this domain; providing a boundary condition for the knowledge density at a level of 4.

The regions that represent the main researches knowledge density concentrations have an initial condition distinct of u_0, where some arbitrary values were given. Those regions are five circular areas in the x-y plane, with a radius of 2. The main one is in the geometric center of the domain, and the others four, accordingly with the examples characteristics are centered at

(2.0,5.0), (8.0,5.0) which are linked by preferential paths to the central region, and (5.0,2.0) and (5.0,8.0) who has not preferential connections with the others knowledge concentrations sub-domains. The central region has an initial knowledge density of 3.04 and the neighbors ones of 3.6 level. For the four examples the transferring factor was taken to be $\beta = 0.5$.

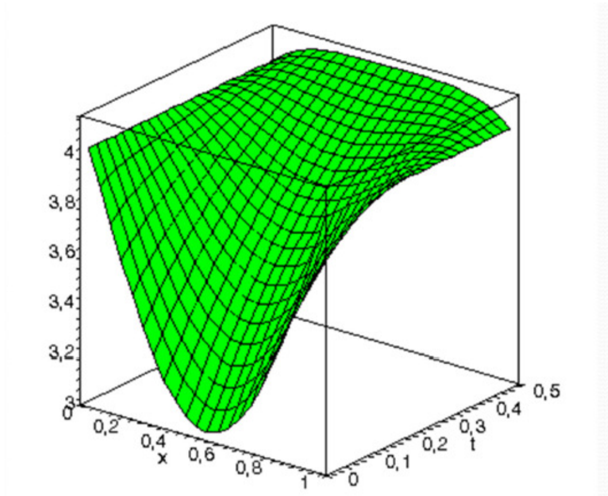

Figure 1 – Knowledge density, u(x,t) in vertical axis, as a time marching on a one dimension research chain

The global domain is discretized in 10.784 P2 triangular finite elements, where the P2 element is concerned to a Hermite polynomial interpolation function, for 32.352 nodal points. The maximum time of simulation may be variable for the experiments, but was fixed in this work for the four experiments, at $T_{max} = 10$, and is representative of the time evolution of the knowledge chain, with time discretization given in one hundred time steps.

The first experiment, fig. 2, is associated with the check of the validity of the evolutionary solution as the knowledge chain net evolves in time, the present bidimensional model example. For this one those same parameters values where adopted, as also $K_4 = 1.0$ in every point of the geometric domain. The diffusion coefficient, inside preferential paths connections, was take as $K_{path} = 1.2$. Convection was taken null and boundary conditions are Dirichlet type ones for $u_\Gamma = 4$. Figure 2 shows the domain with a central nucleus of knowledge density, and two neighbor nucleuses, from which the knowledge is affected by diffusivity and retention as time runs on, as also the isolines of the evolution of the knowledge chain, showing the initial, two intermediary, and the final time steps. We consider that the computational model presents a well evolution behavior, in relation to the one dimensional chain behavior, with a symmetric pattern of isolines, for those presences of a central and symmetrically positioned knowledge density in the research network.

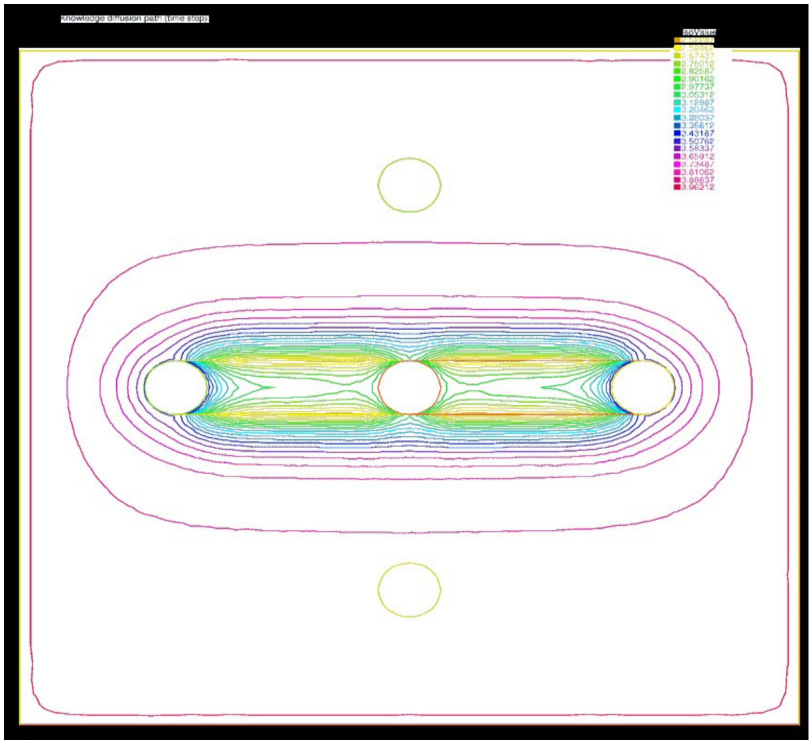

Figure 2a – Evolutionary knowledge chain, Dirichlet condition, high c_p, low diffusion, retention and generation. Results at 0.5 time step

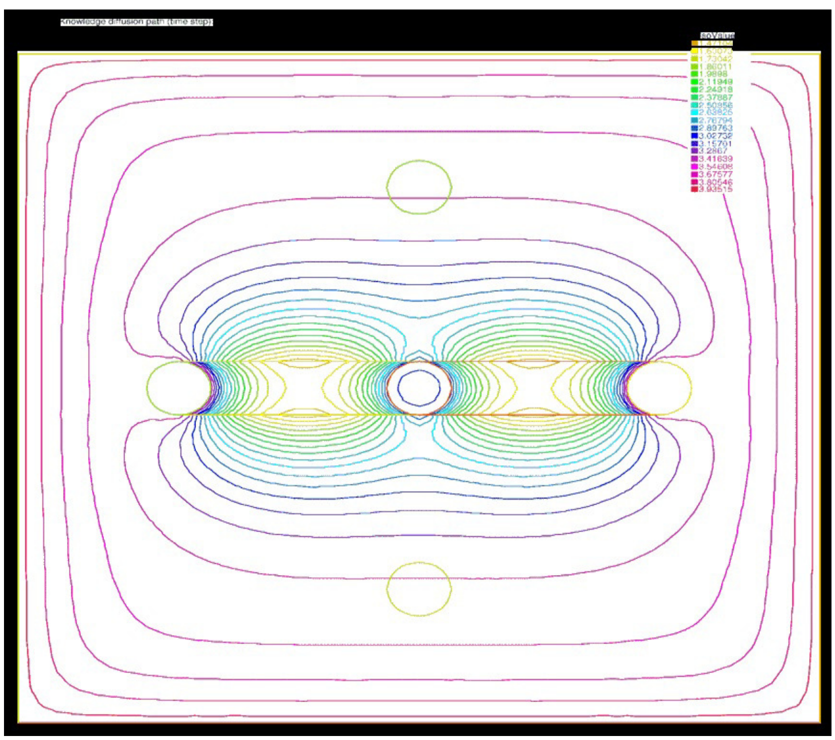

Figure 2b – Evolutionary knowledge chain, Dirichlet condition, high c_p, low diffusion, retention and generation. Results at 30.0 time step

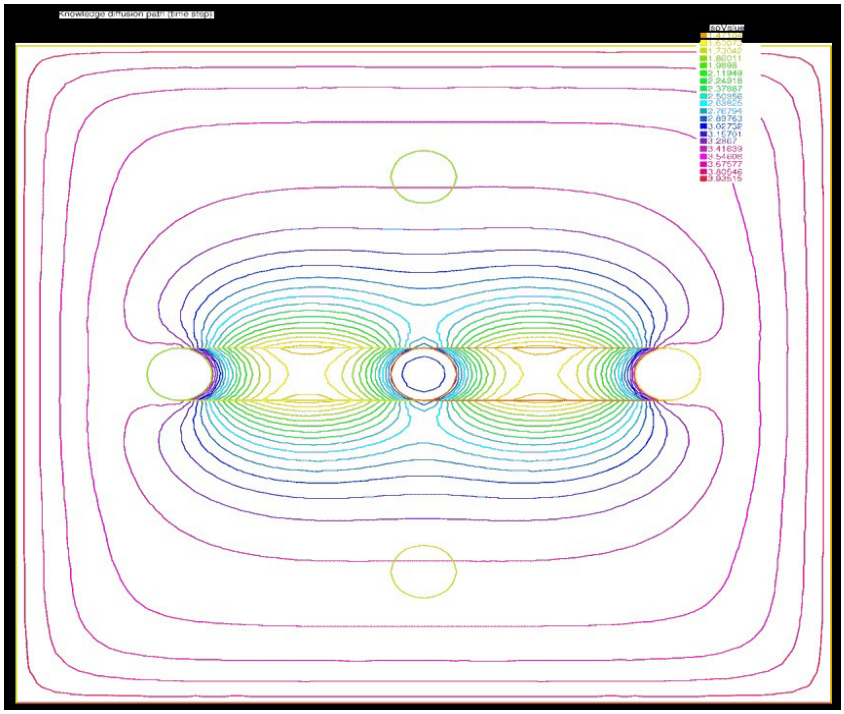

Figure 2c – Evolutionary knowledge chain, Dirichlet condition, high c_p, low diffusion, retention and generation. Results at 70.0 time step

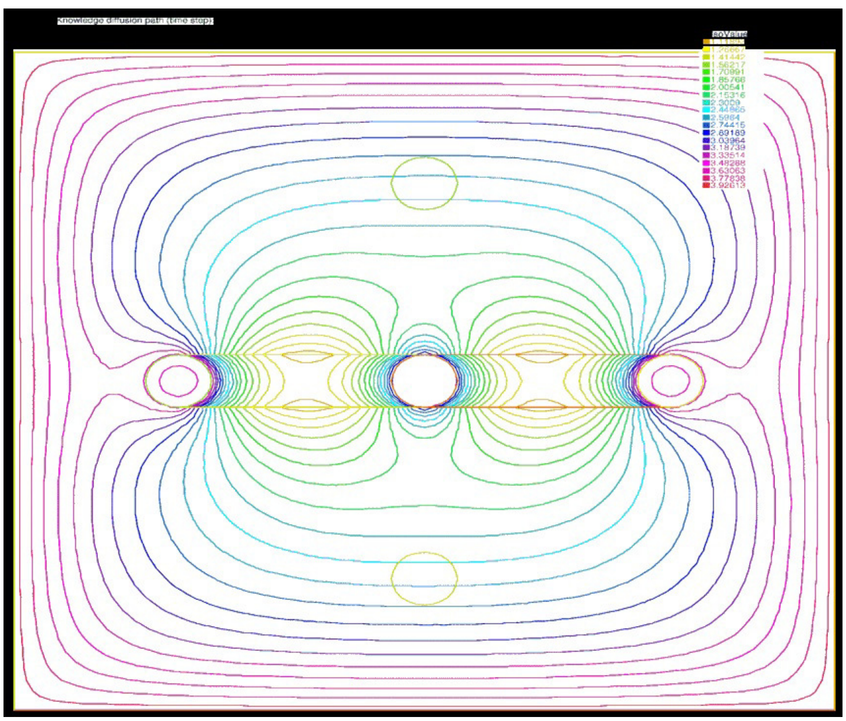

Figure 2d – Evolutionary knowledge chain, Dirichlet condition, high c_p, low diffusion, retention and generation. Results at 100.0 time step

The second example, fig. 3, is analogous to the first one, with the same boundary and initial conditions, but with a growth of retention coefficient value, that is taken as $K_4 = 21.13$ in whole domain of the knowledge chain, without convective effect on the domain. We also change the diffusion coefficient inside preferential paths, taking it as being $K_{path} = 2.13$, allowing a magnification of its influence over the knowledge transferring problem. In this example we check the influence of the retention phenomena on the research chain. In fig. 3 isolines of the evolution of the knowledge chain were given, at an initial, two intermediaries, and at the final time steps.

Absence of researches mobility, along the knowledge chain, results on knowledge revenue that evolves in a concentered way, around the mains research centers of the research chain, fig. 3. The presence of preferential paths to the knowledge diffusion, connecting those main researchers groups, tends to focus the knowledge transferring process into them own. While this cannot be conceptualized as a stagnation of the knowledge domain (or institution) as the main researchers continue to evolve, for some segments – in fig. 3 results, the top and bottom ones – at the neighbor of the central research effort area, this is a reality.

For the third example, fig. 4, we consider the same parameters values of the precedent ones, remembering to be $c_p = 4$, $K_2 = 1.2$ in whole domain, except inside preferential paths where it is taken to be $K_{path} = 2.13$, and $r = 1.0$, taking in account that retention is given by a $K_4 = 21.13$ factor, in whole domain of the knowledge chain.

This third numerical example, fig. 4, does not consider the presence of convection on the domain. Meanwhile we change the boundary conditions. The same Dirichlet one, as taken above, acts on the bottom and left sides of the domain frontiers. A Neumann boundary condition affects the chain evolution, in the outside direction, at the right and top sides of the network frontiers.

The presence of a strong retention behavior, and a low knowledge generation, in presence of a favorable diffusivity along preferential knowledge transfer paths, even in a behavior where the knowledge chains communicates with other researcher systems – the Neumann boundary condition reflects that - , results in a low development of the knowledge density.

This stagnant chain, fig. 4, is a reality across all the whole domain, showing it's development following an initial growth in the knowledge level, but stagnating after a little elapsed time period, and concentrating the knowledge greater effort and results along the intercommunicated nucleus of research. In this behavior, the remaining areas of the knowledge chain rests in a negligible knowledge density level.

This phenomena mimics the natural self-protection behavior of populations and organizations that, when attacked or feel in danger of loss of theirs parts, individuals, or controlled areas, tends to close in their own domain, to preserve forces, power, or capacities (Cavalli-Sforza, Feldman, 1981; Welzer, 2010).

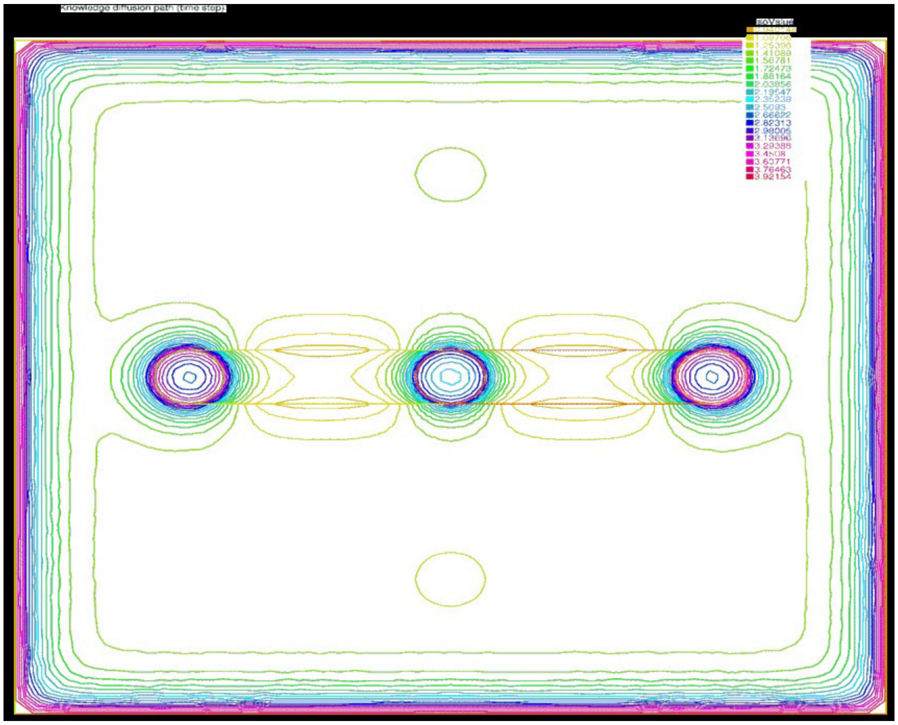

Figure 3a – Evolutionary knowledge chain, Dirichlet condition, high impedance and high retention, low diffusion and generation, preferential paths influence. Results at 0.5 time steps.

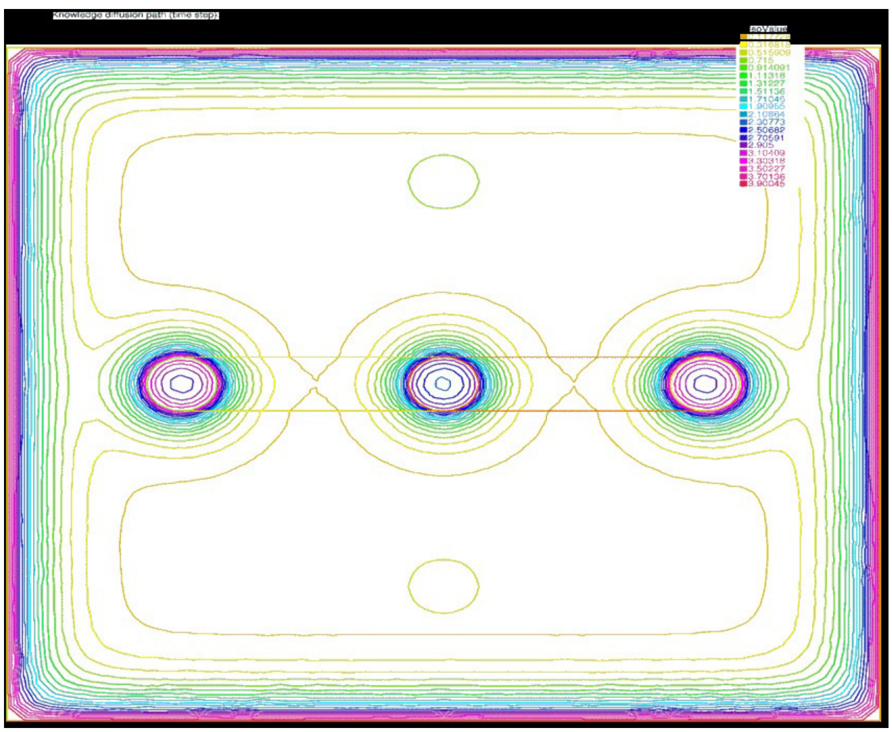

Figure 3b – Evolutionary knowledge chain, Dirichlet condition, high impedance and high retention, low diffusion and generation, preferential paths influence. Results at 30 time steps.

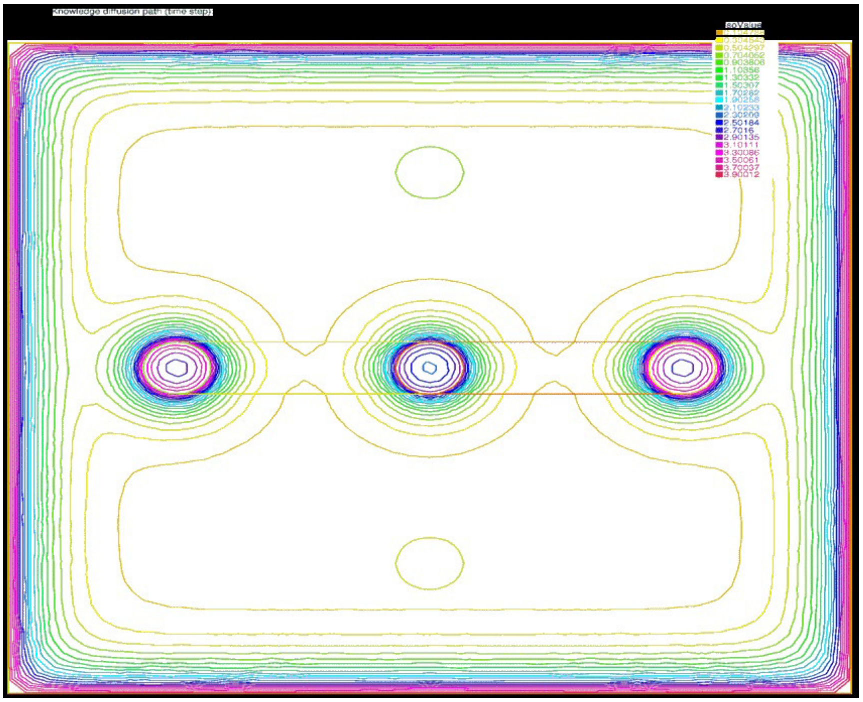

Figure 3c – Evolutionary knowledge chain, Dirichlet condition, high impedance and high retention, low diffusion and generation, preferential paths influence. Results at 70 time steps.

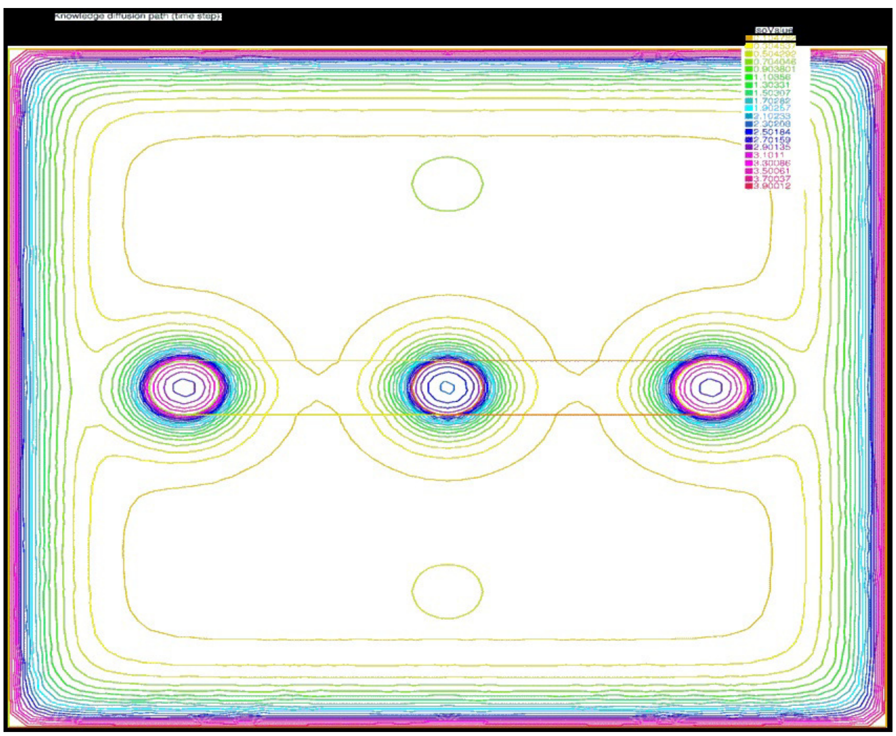

Figure 3d – Evolutionary knowledge chain, Dirichlet condition, high impedance and high retention, low diffusion and generation, preferential paths influence. Results at 100 time steps.

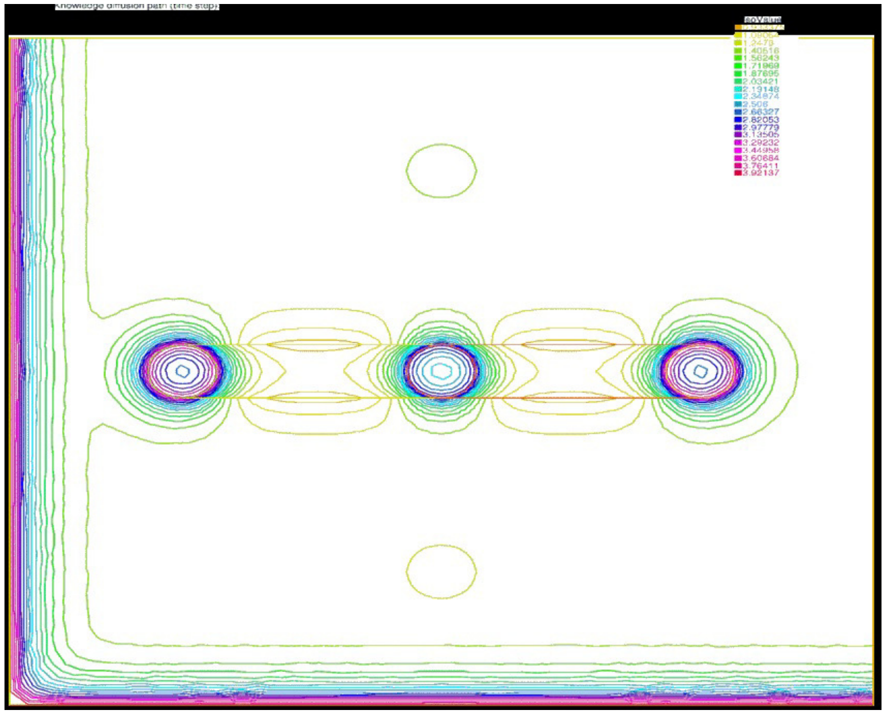

Figure 4a – Evolutionary knowledge chain, Dirichlet and Neumann conditions, no convective. High impedance, retention, and preferential paths diffusion. Results given for 0.5 time steps.

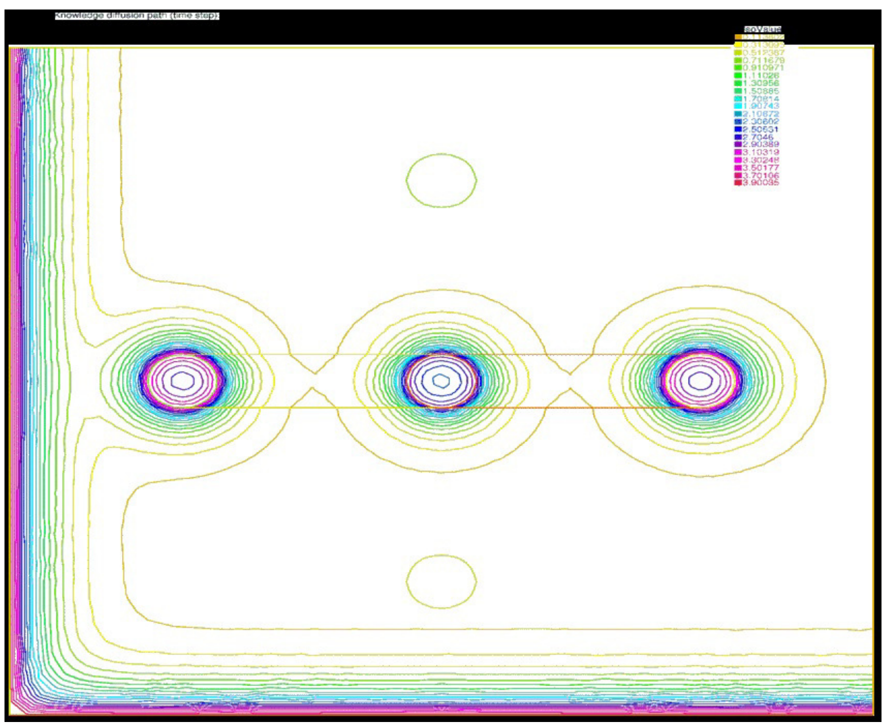

Figure 4b – Evolutionary knowledge chain, Dirichlet and Neumann conditions, no convective. High impedance, retention, and preferential paths diffusion. Results given for 30 time steps.

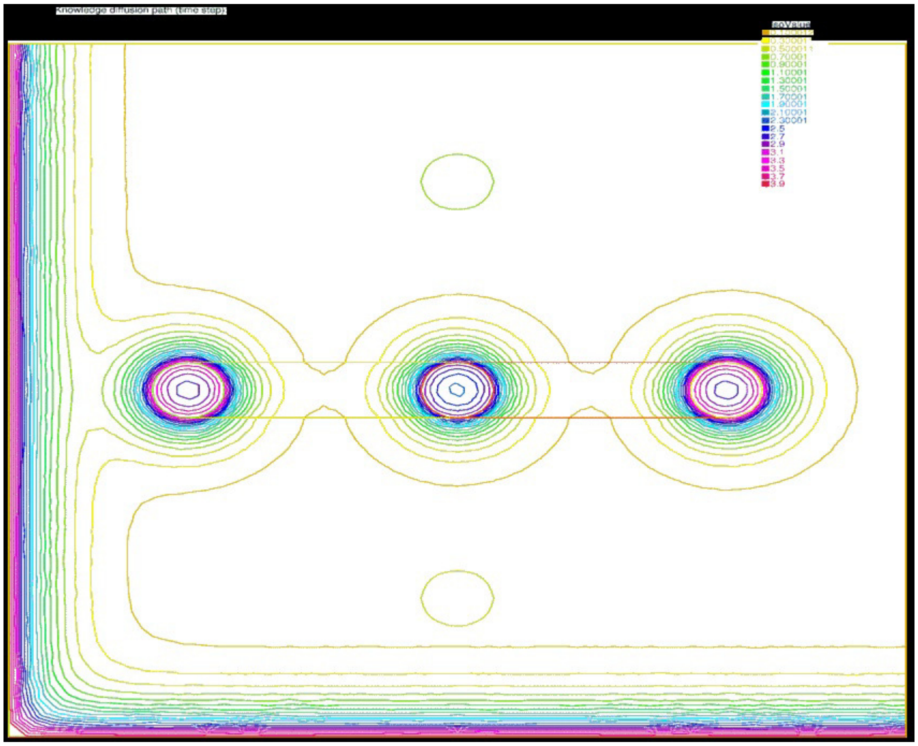

Figure 4c – Evolutionary knowledge chain, Dirichlet and Neumann conditions, no convective. High impedance, retention, and preferential paths diffusion. Results given for 70 time steps.

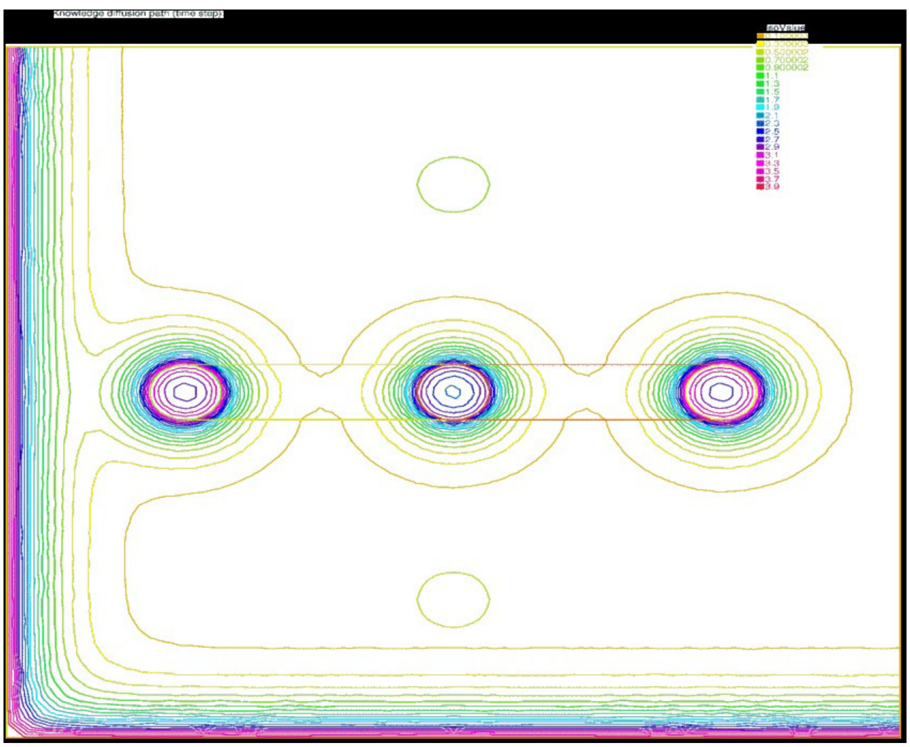

Figure 4d – Evolutionary knowledge chain, Dirichlet and Neumann conditions, no convective. High impedance, retention, and preferential paths diffusion. Results given for 100 time steps.

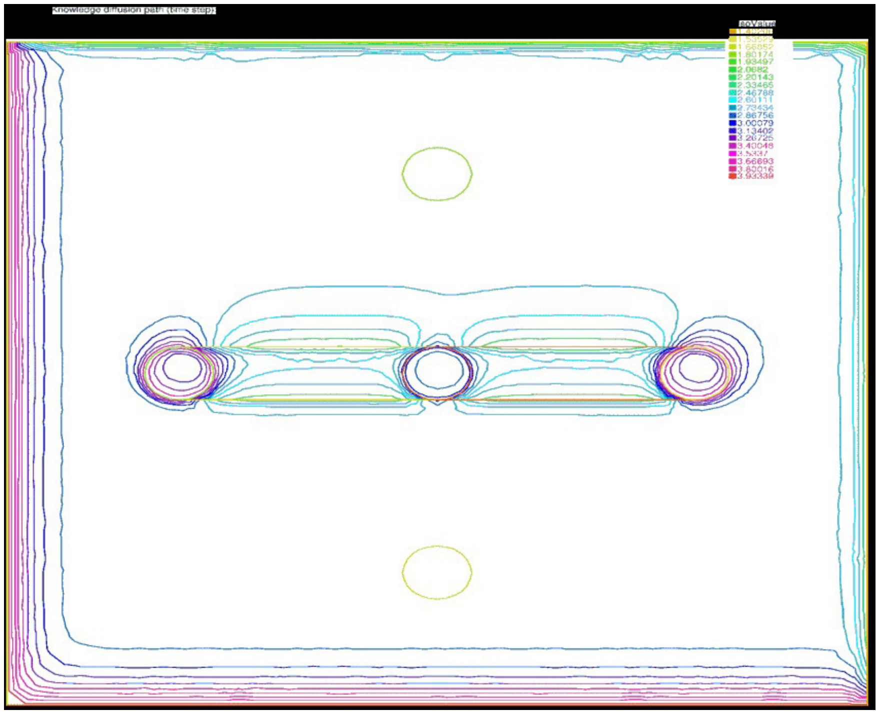

Figure 5a – Convective effect on a knowledge chain, Dirichlet and Neumann conditions. High impedance, retention, and preferential paths diffusion. Results at 0.5 time steps.

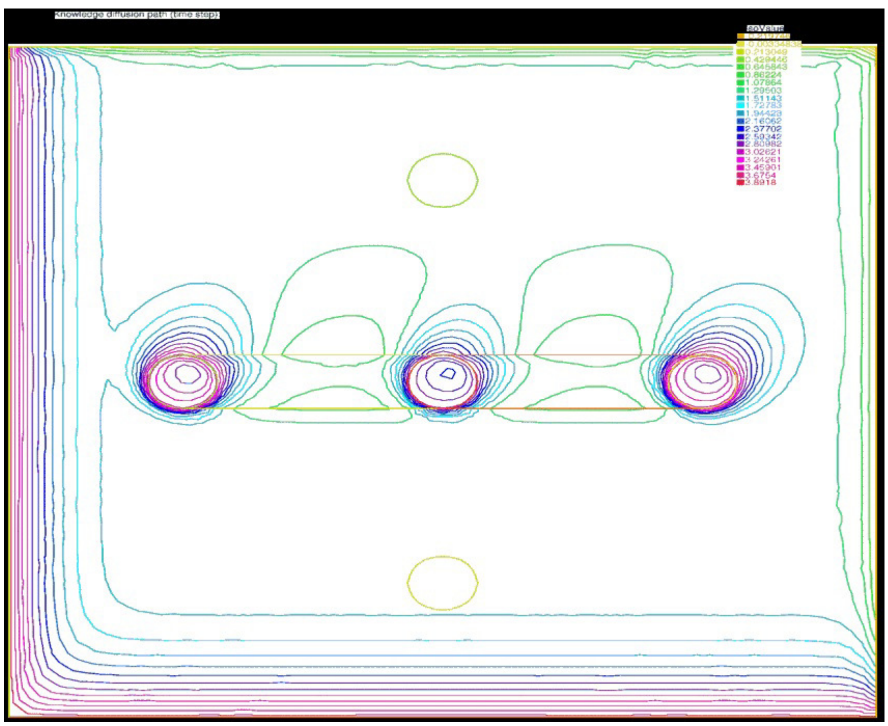

Figure 5b – Convective effect on a knowledge chain, Dirichlet and Neumann conditions. High impedance, retention, and preferential paths diffusion. Results at 30 time steps.

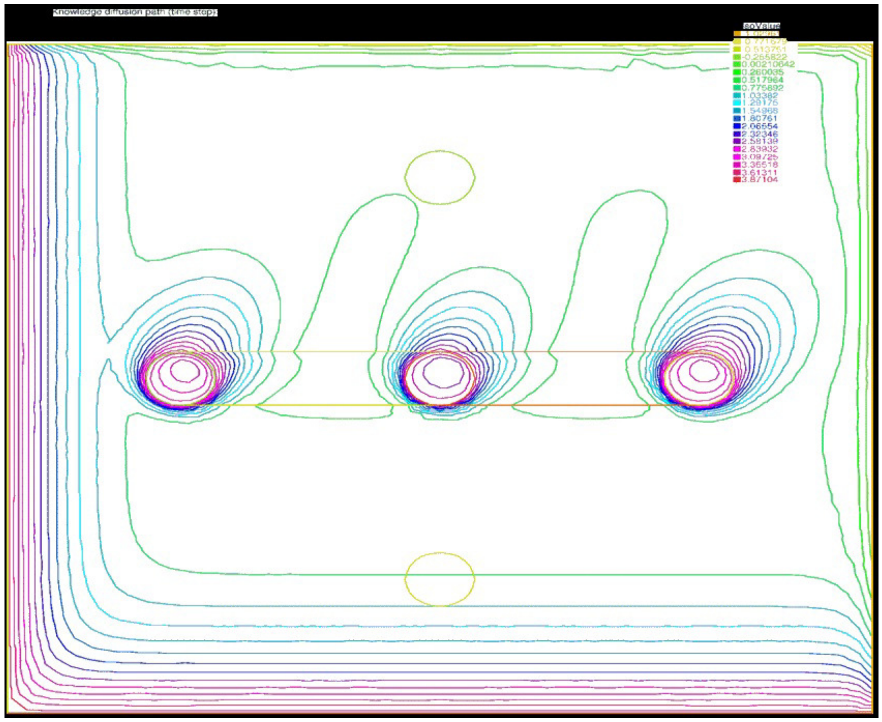

Figure 5c – Convective effect on a knowledge chain, Dirichlet and Neumann conditions. High impedance, retention, and preferential paths diffusion. Results at 70 time steps.

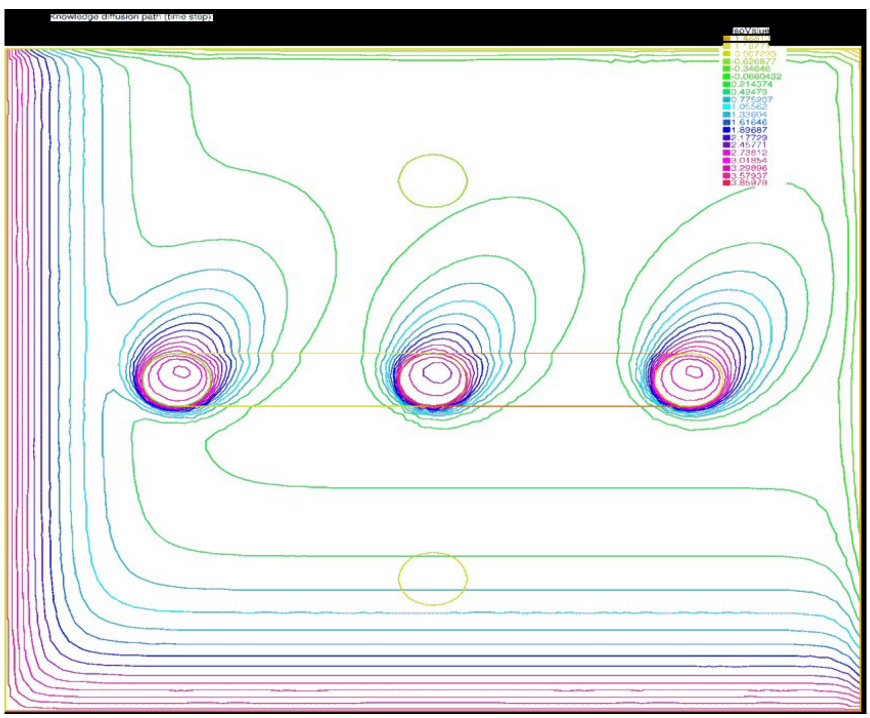

Figure 5d – Convective effect on a knowledge chain, Dirichlet and Neumann conditions. High impedance, retention, and preferential paths diffusion. Results at 100 time steps.

For the fourth and last numerical simulation, fig. 5, characteristic parameters values are taken as the same of the precedent example. In this sense the learning absorption coefficient, or knowledge impedance, is taken as $c_p = 4$, the diffusion coefficient is $K_2 = 1.2$ in whole domain, and is taken to be $K_{path} = 2.13$, inside preferential paths . The knowledge generation continues to the a low value, beeing r = 1.0, taking in account that retention is given by a $K_4 = 21.13$ factor, in whole domain of the knowledge chain.

Is this last example, meanwhile, the convection acts, mirroring the flux of researchers across and to the outside of the knowledge chain. To mimic this effect we adopted a velocity vector being:

$$\mathbf{v} = 2.0\mathbf{i} + 4.0\mathbf{j} \tag{6}$$

where **i** and **j** are normal vectors orthogonal do y and x direction, respectively.

The convection of brains in this network, fig. 5, acts together with retention phenomenon, allowing the evolution of the knowledge chain, into the central intercommunicating region. That is the three main researchers regions linked by preferential paths, and where knowledge generation and revenue results are given. The evolution of the intertwined network occurs, in this behavior even the regions far from the central, and being meaningful along the convective path way, being favorable to the entire chain.

5 CONCLUSIONS

A research chain with low diffusion and also low knowledge generation, even with a high knowledge absorption rate, evolves to a limited knowledge level and then stagnates, if being closed, in a self-contained manner. The presence of a main concentrated leadership, with high knowledge, in this chain net, does not change this behavior.

Absence of researches mobility, along the knowledge chain, results on knowledge revenue that evolves in a concentered way, around the mains research centers of the research chain, in which preferential paths, connecting those center groups, focus the knowledge transferring process into them own.

Knowledge flow across the borders of the knowledge net, in the outside direction, in with retention is strong and knowledge generation is low, even with a favorable diffusivity along preferential knowledge transfer paths, gives a low development rate of the chain net knowledge density.

On the other side, a knowledge chain, as an intertwined network, across with the knowledge brains may convect, in presence of retention, with central intercommunicating region linked by preferential paths, shows an favorable knowledge evolution, with knowledge concentration, or, that's the same, knowledge leading groups summing and accumulating knowledge, in a way to growth the net knowledge density in the neighborhood of their own.

6 ACKNOWLEDGEMENTS

This work was partially supported by CNPQ through the research productivity grant 310394/2013-9, and by the project "Sistemas complexos de propagação de conhecimento: soluções iterativas e aplicações tecnológicas".

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