STONE AGE CULTURE AND DIFFUSION IN ANNEALED RANDOM MEDIA

M. A. Radwan[1], M. A. Sumour[1], A. H. El-Astal[1] and M. M. Shabat[2]

[1] Physics Department, Al-Aqsa University, P.O.4051, Gaza, Gaza Strip,Palestinian Authority.
ma.radwan@yahoo.com , msumoor@yahoo.com , a_elastal@yahoo.com

[2] Physics Department, Islamic University of Gaza, P.O.108, Gaza, Gaza Strip. Palestinian Authority
shabat@iugaza.edu.ps

ABSTRACT

Symbolic and technological complexity of human artifacts increased drastically around 45,000 years ago. Powell, Shennan and Thomas (2009) explained it using a computer simulation of a demographic model through an increase of the population density. We have simplified the computer demographic model to be similar to standard physics models (percolation, random walks) for a large square lattice. Demography is a major determinant in the maintenance of cultural complexity and its variation in regional subpopulation density and/or migratory activity results in spatial structuring of cultural skill accumulation. Computer simulations have been used to facilitate information spread by random walkers over dozens of distances between human bands (extended families) of stone-age humans, distributed randomly on a large square lattice such that each lattice site is randomly occupied with probability p and empty with probability 1−p, and random walkers move among the occupied sites only.

In this paper we allow also these bands to move randomly on the lattice. This improvement has been done by letting the communities perform slower random walks on the lattice such that no sharp percolation threshold exists for the random walks of the walkers within groups of occupied neighboring sites..

KEYWORDS

Sciophysics, Stone- age, Random walk, Human Artifacts, Computer Demographic model, Square Lattice, Neighboring sites.

1. INTRODUCTION

Modern humans presumably originated about 200,000 years ago in East Africa. They emigrated to 150 km north of Gaza (Skhul near Haifa) about 100,000 years ago but died out there again. Then about 50,000 years ago they again emigrated from Africa, this time more successfully, but presumably again via Gaza and Haifa. Perhaps [1] there was only one such emigration, 10^5 years ago and immediately successful.

The rapid progress of human culture about 45,000 years ago was simulated by Powell et al. [2] in 2009 as being due to increased population density. In 2011 we [3] achieved the same result through standard percolation theory [4], where teachers randomly visit neighboring communities distributed randomly and fixed on a square lattice; these teachers teach the visited communities new techniques. For the above purpose it was assumed [3] that bands, which defines the extended families, of stone-age humans were distributed randomly on a square lattice such that each lattice site is randomly occupied by one band with probability P and empty with probability 1 – P. Information then spreads randomly from an occupied site to one of its occupied neighbors. The diffusing information was given a finite lifetime, which shifts the threshold upwards.

Each random walk starts on an allowed site, and then for each time step a walker (= teacher) tries to move to a neighbour site. If the selected neighbour is empty (= prohibited), the walker remains at its old position, otherwise it moves to it. In both cases, time increases from t to t+1. Information in this way spreads randomly from an occupied site to one of its occupied neighbors. These computer simulations have been used to facilitate information to spread over dozens of distances between human bands (extended families) of stone-age humans, distributed randomly on a large square lattice such that teachers move among the occupied sites (= bands) only.

In this paper we allow also these bands to move randomly on the lattice, i.e. annealed disorder rather than quenched disorder [5]. This improvement has been done by letting the communities perform slower random walks on the lattice such that no sharp percolation threshold exists for the random walks of the teachers within groups of occupied neighboring sites. Otherwise we use our model of the previous publication [3] with random walks of the teachers. The walkers progress has then to be checked for intermediate times and intermediate lattice sizes for realistic human applications [6].

2. DATA AND SIMULATIONS

A short FORTRAN program as shown in the appendix has been used in our work. The size of square lattice L_x=100 and L_y=100 has been considered, with number of neighbors m=4 and occupation probability Prob [=0.10,0.20,0.30, 0.40,0.50,0.52,0.54,0.56,0.58,0.60,0.70,0.80,0.90] (= density; percolation threshold 0.593) which means that for large lattices you never reach the other side, if the occupied sites never move.

With another probability Pro (0.10 to 0.90) whenever of two neighboring sites one is occupied (site) and the other empty, they are exchanged, which means one site moves to an empty neighbor area.

We check after which time (iterations= 100,000 and 1000,000), i.e. after how many jump attempts, the walkers made a random walk across the whole lattice in x-direction. There are nine samples (nine random walkers) from which the median is defined such that four times are larger and four times are smaller than the median time.

The obtained data are presented in the following table:

Table 1. Heading and text fonts.

	MC (TIME, ITERATION-1000,000)	MC (TIME, ITERATION-100,000	MC (TIME, ITERATION-1000,000)	MC (TIME, ITERATION-100,000)
	AVERAGE OVER PRO (0.2-0.9)	AVERAGE OVER PRO (0.2-0.9)	PRO = 0.1	PRO = 0.1
	MEDIAN FROM 9 SAMPLES	MEDIAN FROM 9 SAMPLES	MEDIAN FROM 9 SAMPLES	MEDIAN FROM 9 SAMPLES
0.10	192007	*****	47770	*****
0.20	95179	77335	184126	*****
0.30	59485	49227	170976	71950
0.40	65893	51075	63155	63155
0.50	40676	41812	31916	31916
0.52	45212	41536	37763	65109
0.54	37169	37994	43236	49267
0.56	39496	33387	24374	41640
0.58	31620	34346	61719	58544
0.60	27429	31991	42006	42006
0.70	25830	26225	17502	18144
0.80	24940	24940	39377	39377
0.90	16444	16444	11162	11162

The stars in the table indicate that more than four samples do not reach the other side, meaning that the median from nine samples was larger than our maximum number of iterations, 10^5or 10^6 Thus when we plot column 1 versus columns 2 , 3, 4 and 5, we get figure (1), which describes the median of the nine samples averaged over Pro from 0.20,0.30,…0.90 and the median of nine samples with Pro = 0.1, both with different probability (density) Prob. The separate symbols describe the median of nine samples from Pro equals 0.1 with different probability (density).

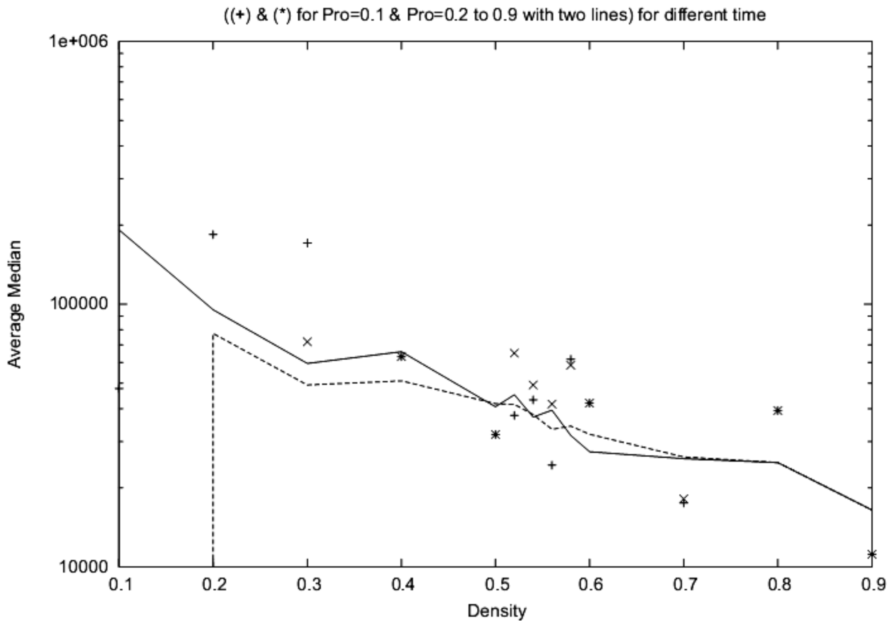

Figure 1: Average median versus density with number of iterations= 100,000 & 1000,000 averaged over Pro = 0.2 to 0.9 with lines and (*,+) for Pro= 0.1.

Figure (1) shows that there are lots of fluctuations but overall Pro = 0.1 gives longer times than Pro = 0.2 to 0.9.
We repeat our simulations with different L_x=10, 20, 30, 40, 50, 100, 200, 300, at constant L_y=100 , with Prob = Pro = 0.50.

Then we plot the different L_x versus the median as shown in figure 2.

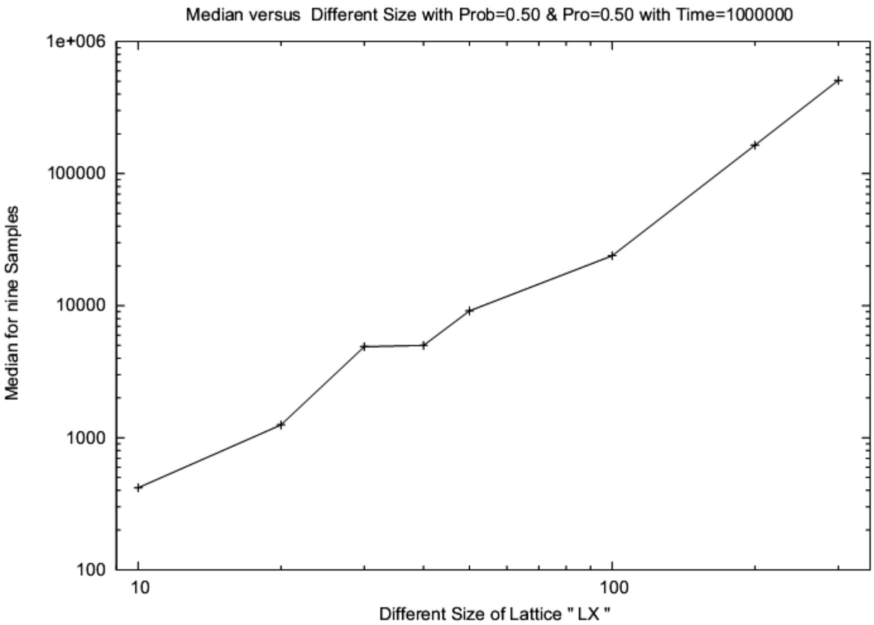

Figure 2: Median time versus L_x for L_y=100, at Prob = Pro = 0.50, time=1000,000

3. CONCLUSIONS

Our results show that for the time to cross the lattice only a weak variation with the mobility of the villages (Pro between 0.1 and 0.9), a moderate variation with the density (Prob between 0.1 and 0.9) and a strong variation with the distance the teachers are asked to cross (L_x between 10 and 300). For L_x = 100, most times are larger than the reasonable limit 10,000 for visits of one teacher during one human generation.

4. ACKNOWLEDGEMENT

The authors would like to thank Prof. Stauffer for many valuable suggestions, fruitful discussions and constructive advice during the development of this work.

5. APPENDIX

```
parameter(Lx=100,Ly=100,L2=Lx*Ly,m=4,iseed=1,Lmax=(Lx+2)*Ly)
  real*8 prob, pro
  integer*8 ibm,ip,ipro
```

```
      integer*4 ibn
      dimension is(Lmax),neighb(m)
      byte is
      data max,mc,prob/9,100000,0.4d0/
      do 9 iprobability=900,100,-100
      pro=0.001*iprobability
      neighb(1)=-1
      neighb(2)=+1
      neighb(3)=-Ly
      neighb(4)=+Ly
      open (unit=60,file='prob04100000.data')
      write (60,*) '# Lx,Ly,max,mc,iseed,prob,pro',Lx,Ly,max,mc,iseed,
     1   prob,pro
      ibm=2*iseed-1
      ibn=ibm+2
      factor=(0.25/2147483648.0d0)/2147484648.0d0
      ip=2147483648.0d0*((4.0d0*prob)-2.0d0)*2147483648.0d0
      ipro=2147483648.0d0*((4.0d0*pro)-2.0d0)*2147483648.0d0
      do 1 i=1,Lmax
       is(i)=-1
       ibm=ibm*16807
       if(ibm.lt.ip)   is(i)=1
1     continue
      do 3 nstep=1,max
4     ibm=ibm*16807
      j=Ly+1+(ibm*factor+0.5)*Ly
      if(j.le.Ly.or.j.gt.Ly+Ly) goto 4
      do 100 k=1,mc
       ibn=ibn*16807
       jnew=j+neighb(1+ishft(ibn,-30))
       if(jnew.le.Ly) goto 100
       if(is(jnew).eq.1)     j=jnew
       if(j.gt.(Lmax-Ly)) goto 3
       ibm=ibm*16807
       if(ibm.gt.ipro) goto 100
       do 20 move=1,L2
6         ibm=ibm*16807
        nb=Ly+1+(ibm*factor+0.5)*L2
        if(nb.le.Ly.or.nb.gt.l2+Ly) goto 6
        ibn=ibn*16807
        nc=nb+neighb(1+ishft(ibn,-30))
        if(is(nb).ne.is(nc)) then
         is(nb)=-is(nb)
         is(nc)=-is(nc)
        end if
20     continue
100   continue
3     write (60,*)'# i,j,is(j),jnew,nstep,k,nb,nc', i,j,is(j),jnew,
     1   nstep,k,nb,nc
9     continue
      stop
      end
```

6. REFERENCES

[1] E. Callaway, Nature 489, 343 (2012).
[2] A. Powell, S. Shennan and M. G. Thomas, Science 3214, 1298 (2009).
[3] M. A. Sumour, M. A. Radwan, M. M. Shabat and A. H. El-Astal, Int. J. Mod. Phys. C22, 1352 (2011).
[4] D. Stauffer and A. Aharony, Introduction to Percolation Theory, Taylor and Francis, London 1994 (2nd printing of 2nd edition)
[5] R. Kutner and K. W. Kehr, Phil. Mag. A 48, 199 (1983).
[6] S. Shennan, Cambridge Arch. J. 11, 5 (2001); F. W. S. Lima and D. Stauffer, Int. J. Mod. Phys. C 23, 1250007 (2012).

Authors

Dr. Mohammed A. Radwan was born in 1963, Gaza, Palestinian Territories. In 1985 he got his B.Sc in Physics from Acute University in Egypt. In 1991 he obtained the M.Sc. in Solid State from the Arab Saudi University. In 2000 he was awarded the Ph.D. in Electronic solid State from the Ein shams University of Egypt. In 1992 he was appointed as an lecture in physics at department of physics, Al-Aqsa University, Gaza, Palestine. He published various refereed papers on solid state physics and other related topics and participated in many conferences.

.

Dr. Muneer A. Sumour was born in 1967, Gaza, Palestinian Territories. In 1996 he got his B.Sc in Physics from Islamic University in Gaza in Palestine. In 2005 he obtained the M.Sc. in Computational statistical Physics from Islamic University in Gaza in Palestine. In 2008 he was awarded the Ph.D. Computational statistical Physics from the Ein shams University of Egypt. In 1998 he was appointed as an lecture in physics at department of physics, Al-Aqsa University, Gaza, Palestine. He published various refereed papers on Computational statistical Physics and other related topics and participated in many conferences.

Prof. Ali Hamed El-Astal was born in 1964, Gaza, Palestinian Territories. In 1986 he got his B.Sc in Physics & Maths from UAE University. In 1991 he obtained the M.Sc. in optoelectronics and optical information processing from the Queen's University of Belfast,UK. In 1995 he was awarded the Ph.D. in laser physics and spectroscopy also from the Queen's University of Belfast,UK. In 1996 he was appointed as an assistant professor in physics at department of physics, Al-Aqsa University, Gaza, Palestine. In 2008 he was promoted as a full professor in laser physics at Al-Aqsa University. He worked as a dean of postgraduate studies and scientific research within the periods 2003-2004 and 2006-2010. From November 2010 he has worded as Al-Aqsa Vice president. He published various refereed papers on laser physics and other related topics and participated in many conferences.