



Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Lecture with Computer Exercises:
Modelling and Simulating Social Systems with MATLAB

Project Report

SIMonkey
Modelling social affiliation in gelada baboons

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Zurich
December 2014

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1 Abstract

The social structure of gelada baboons is very interesting. Geladas form two different groups, a reproductive unit and an all-male group. In the reproductive unit are about one male and one to twelve females. The male often have one predominant female partner but can also interact with the others of his females. The females form strong social bonds and a hierarchy in which closely related females tend to have the same hierarchical status.[1],[2]

In this report we present a model to simulate social affiliation in monkeys, GrooFiWorld.[3] With this model as base we tried to simulate the social structure of gelada baboons. With the simulation we can show that it's possible to reduce the structure of social behaviour of gelada baboons to only for variables for each baboon. Grooming, fighting, dominance and anxiety.

2 Individual contributions

As we are a group, we all worked together on this project. We had nearly every week a team meeting and discussed as many as possible together. But of course not every one can do everything, so we splitted the work as follows.

Derk Wild had most of the ideas what we can do and searched for good material to work on. In the end he also did programming work. Michael Heutschi and Frank Grossenbacher started with the first implementation of the model and developed the foundation of our code. They worked whole nights to enhance the code as good we can. Me, Sofia Zbinden, I worked mostly on the report and did the organization of our group.

3 Introduction and Motivations

3.1 Introduction: Social structure of gelada baboons

Gelada baboons are very interesting and in their own way beautiful monkeys. They have long, grey and brown fur. The males are bigger than the females and have a red triangle on their chest (Figure 1).

Gelada baboons live in one of the most complex social structures among the whole animal kingdom. They form a so called multi level society where the females live in a harem with only one male in it (Figure 2). This harem, called reproductive unit, contains one to twelve females. The rest of the male monkeys form pure male groups, the all-male groups.[4],[5],[6]

In the reproductive unit the male often have one predominant female partner, but he

can also interact with his other females. But only the dominant female can monopolize the male if she wants. However she only does it if she has no alternative.[7] This relationship between the male and his predominant female is similar to the especially relationship among the females. Very interesting are the strong bonds the females build.[4] They form a hierarchy in their group in which closely related females tend to have the same hierarchical status.[2]

In the all-male groups they are some subadults and one young adult. The young adult is led by one male of the group.[1] Within the group aggression is not really remarkable, like in the reproductive units, but towards other groups there's lots of aggression based on the all-male group.[1],[8]

In the reproductive and the all-male unit grooming is a very frequent activity. It has several functions which are: cleaning the fur, reducing anxiety, tension and stress, social bonding, repairing relationships and social reciprocation and exchange.[3] Mostly grooming occurs between individuals of a similar rank because they have similar needs, but it occurs also between two former opponents after a fight.[3] After a fight the baboon of lower rank grooms the other one.

In every group some gelada baboons of similar hierarchical status have a very strong relationship. The quality of this relationship is influenced by security, value and the compatibility of both partners.[3]



Figure 1: Male Gelada Baboon in Simien Mountains, Ethiopia.

Source: National Geographic, Photo and caption by Brian Shuchuk: A moment captured during a trek in the Simien Mountains National Park, Ethiopia in November 2012.



Figure 2: Gelada reproductive unit.

Source: <http://en.wikipedia.org/wiki/Gelada> (09.12.2014)



Figure 3: Male gelada grooming a female.

Source: <http://en.wikipedia.org/wiki/Gelada> (09.12.2014)

3.2 Motivation

As we searched for good, already existing models of the social structure of monkeys we found one that we can use for our project. The model we found is called GrooFi-World and is published by Gonzalez et al. in 2009.[3] It's a model for 'emergent patterns of social affiliation in primates'.[3]

We decided to take this model as a base and apply some changes to it to get a simu-

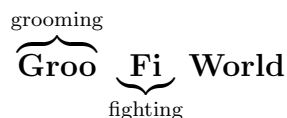
lation of grouping of monkeys. We want to simulate the interesting social structure of the gelada baboons, to find out what are the important variables and parameters for the model and to get the grouping to a harem.

At the end our question is, if it's possible to get this form of grouping of females around one male if we only consider two variables for activities of the baboons and two variables of the well-being of the baboons.

4 Description of the Model

4.1 GrooFiWorld

As mentioned in section 3.2 of this report, we used the model GrooFiWorld as base of our model. GrooFiWorld is an Agent-Based model written in C++.[3] The model is based on two frequent activities of monkeys. Grooming and fighting, as represented in it's name.



The World is without any borders, it is continuous and the mokeys are free to move in any direction. The monkeys have a certain angle of vision in which they can see others and can interact with them.

The monkey's well-being is displayed with theirs dominance (DOM) and anxiety (ANX). When the monkeys groom, they reduce their own anxiety and are out of fear of being defeated. But also, grooming reduces the motivation to be groomed or to groom again. Not being groomed after some time increases the monkes's anxiety and increases their motivation to be groomed or to groom. Anxiety also changes with fighting. After a fight of two mokeys the anxiety is increased for both individuals.

When two individuals meet they first decide whether or not to attack. This desicion depends on the dominance of the two. Higher dominance of the other monkey means higher risk of losing the fight. A fight is only initiated when an individual expects to win. If it expects to lose the individual makes a decision of grooming the other one. After a fight the anxiety grows for both individuals. The decision to go into a fight (mental fight) and the real fight are presented in equation 1. This equation is based on the relative dominance of two monkeys (individual i and individual j) and a random number between zero and one. If the result is 1 the individual i is a winner, else if the result is 0 the individual i loses.

$$w_i = \begin{cases} 1 & , \frac{DOM_i}{DOM_i + DOM_j} > RAND(0, 1) \\ 0 & , \text{else} \end{cases} \quad (1)$$

After a fight the dominance values get updated presented in equation 2 for the monkey i and in equation 3 for the monkey j . The value stepDom is a scaling factor for the dominance. It's between zero and one. The loser of the fight flees over a given distance in a random direction.

$$\text{DOM}_i = \text{DOM}_i + (w_i - \frac{\text{DOM}_i}{\text{DOM}_i + \text{DOM}_j}) \cdot \text{stepDom} \quad (2)$$

$$\text{DOM}_j = \text{DOM}_j - (w_i - \frac{\text{DOM}_j}{\text{DOM}_i + \text{DOM}_j}) \cdot \text{stepDom} \quad (3)$$

When an individual made the decision not to fight, it makes the decision of grooming. The monkey makes this decision with it's present value of anxiety and a random value between zero and one. The monkey grooms if $\text{ANX} > \text{RAND}(0,1)$, else no interaction occurs.

During periods without grooming, periods of no interaction, the anxiety of the monkeys increases.[3]

Figure 4 of [3] shows the structure of the model GrooFiWorld. It is splitted in interaction and grooming and shows all activities and decisions a monkey do in which order.

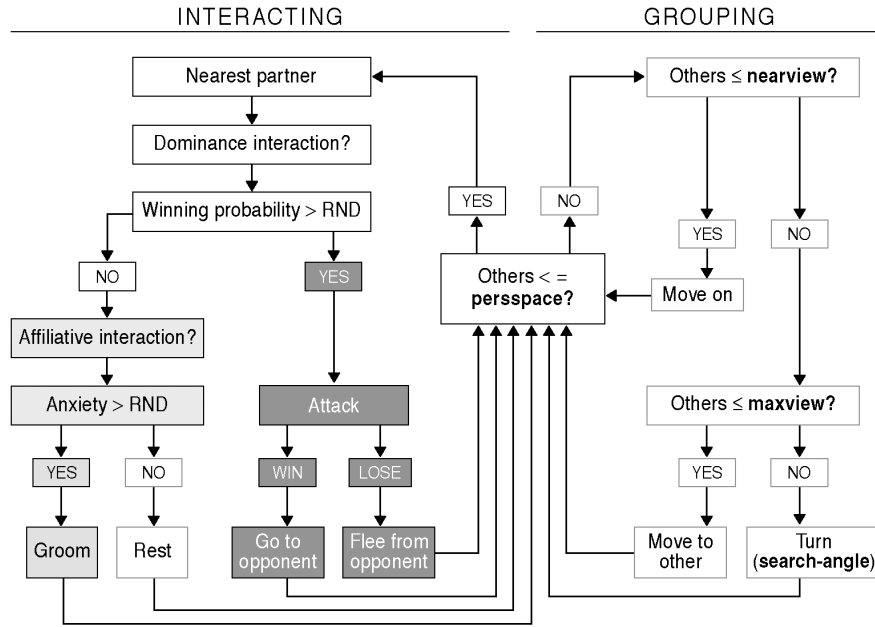


Figure 4: Structure of the model GrooFiWorld.[3]

4.2 SIMonkey

For our simulation a similar structure than used in GrooFiWorld was chosen. However, the program was simplified significantly by adding no directionality to the baboons so they have 360° view angle and movement. Therefore the structure had to be slightly changed to still achieve grouping. The Structure is shown in Figure 5. The first addition is that an individual remembers with whom it just interacted and does not interact with that individual in the next round. This scheme enables grouping. A second addition to achieve harem like groups is the discrimination between alpha male and normal individuals. The alpha male behaves a bit different than the others. It seeks only for male individuals for interaction and since its dominance and therefore winning probability is the highest of all, it is likely to perform a fight and therefore chases the males within its view.

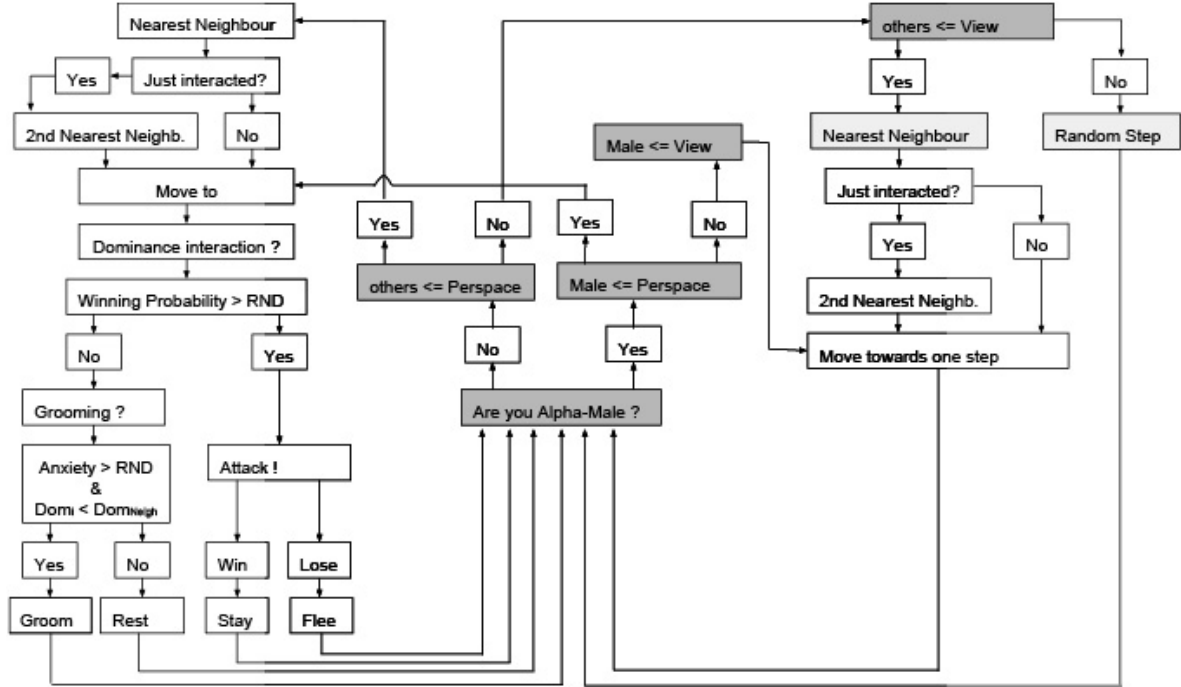


Figure 5: Structure of the model SIMonkey.

5 Implementation

We used the model GrooFiWorld as base. But we implemented the whole code by ourselves new in matlab. We used the ideas from the model and adopt some variables but choosed new names.

The structure of our algorithm is presented in figure 6. First the initial and boundary conditions are set. Then there is a first loop over time and in this loop there is a loop over all baboons. The active baboon, individual i , first searches for the nearest baboon and checks if this baboon is near enough for an interaction. If yes, individual i interacts with individual j . Else there's no interaction and the active baboon makes a random move. In the end the results get visualized in a plot.

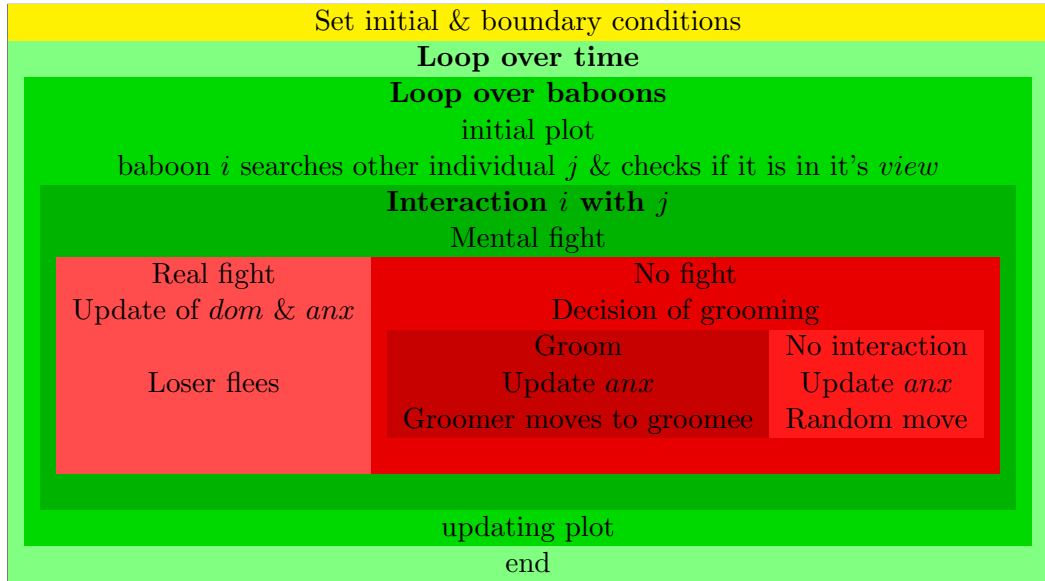


Figure 6: Structure of the algorithm. A time loop in which there is a loop over all individuals and their interactions with each other.

6 Simulation Results and Discussion

7 Summary and Outlook

7.1 Summary

Our results from the simulation are very satisfying. The fundamental problem we confronted us with, to simulate baboons which form groups, is succeeded. The grouping is showed very good and we reached a simple but conceptional well representation of the simulation.

But there are some critical problems we wanna point out here. The harem is not build as good we hoped to. We have the group builing, but not always with only one male and the others females. This is the problem because we implemented that the baboon with the highest dominance is the alpha animal. In nature it's not only dominance that make up an alpha animal. In nature an animal with high dominance has first to fight against the present alpha animal and win against it.

7.2 Outlook

For the future it would be good to overwork the problem with the harem building. And in addition to that one could include directionality to the baboons so they have a view angle and can turn.

7.3 Thanks

We want to thank the whole MSSSM group of the chair of sociology, especially Tobias Kuhn and Olivia Woolley for their great help and good inputs.

8 References

References

- [1] Robin Dunbar and Patsy Dunbar. Social dynamics of gelada baboons. *Contributions to primatology*, 6:1–157, 1974.
- [2] RIM Dunbar. Determinants and evolutionary consequences of dominance among female gelada baboons. *Behavioral Ecology and Sociobiology*, 7(4):253–265, 1980.
- [3] Ivan Puga-Gonzalez, Hanno Hildenbrandt, and Charlotte K Hemelrijk. Emergent patterns of social affiliation in primates, a model. *PLoS computational biology*, 5(12):e1000630, 2009.
- [4] RIM Dunbar. The social ecology of gelada baboons. *Ecological aspects of social evolution: birds and mammals*, pages 332–351, 1986.
- [5] John Hurrell Crook. *Gelada baboon herd structure and movement. A comparative report.* na, 1966.
- [6] Cyril C Grüter, Dietmar Zinner, and Deutsches Primatenzentrum. *Nested societies: convergent adaptations of baboons and snub-nosed monkeys?* German Primate Center, 2004.
- [7] RIM Dunbar. Structure of gelada baboon reproductive units. iii. the male’s relationship with his females. *Animal Behaviour*, 31(2):565–575, 1983.
- [8] Robin Ian MacDonald Dunbar. *Reproductive decisions: an economic analysis of gelada baboon social strategies.* Princeton University Press Princeton, NJ, 1984.
- [9] RIM Dunbar. Structure of gelada baboon reproductive units: I. stability of social relationships. *Behaviour*, pages 72–87, 1979.
- [10] M Kawai, H Ohsawa, U Mori, and R Dunbar. Social organization of gelada baboons: social units and definitions. *Primates*, 24(1):13–24, 1983.
- [11] H Ohsawa and RIM Dunbar. Variations in the demographic structure and dynamics of gelada baboon populations. *Behavioral Ecology and Sociobiology*, 15(3):231–240, 1984.

9 Appendix

9.1 MATLAB code

Listing 1: main: SIMonkey_live.m

Listing 2: function: dist.m

```
function [ dist ] = dist(xpos,ypos,i,j)

dist = norm([xpos(i),ypos(i)]-[xpos(j),ypos(j)]);

end
```

Listing 3: function: dommax.m

```
function [ king ] = dommax(dom)

dom_j = dom(1);
nr_j = 1;
for j = 2:length(dom)
if dom(j) > dom_j
    dom_j = dom(j);
    nr_j = j;
end

king = nr_j;
end
```

Listing 4: function: move_away_random.m

```
function [ coordinate_new ] = move_away_random(coordinate ,
flee_dist , direction)

% move towards point 0.5/0.5 when overshoot 90% of field size
%if abs(0.5-x) > (f-0.5)*0.9
%    y = x+(0.5-x)*d;
% move randomly
%else
%    y = x+d*cos(2*pi*rand);
```

```

%   while -f+1 > y || f < y
coordinate_new = coordinate+flee_dist*direction;
%   end

% Fehlt:
% Fluechte nicht zum feind HIN!
% Fluechte nicht ueber feldrand!

end

```

Listing 5: function: plotall.m

```

function [ ] = plotall(xpos,ypos,gender,spawning_size,
field_size,gela_nr,alpha)

% Plot whole Playground
subplot(1,3,1:2);
plot(xpos(1),ypos(1),'.','MarkerSize',40,'Color','w');
hold on;
for j = 1:length(xpos)
    if (gender(j) == 0 && alpha ~= j)
% females
        plot(xpos(j),ypos(j),'.','MarkerSize',40,'Color',
            '[1,0.4,0.9]');
        else if (gender(j) ~= 0 && alpha ~= j)
% normal males
        plot(xpos(j),ypos(j),'.','MarkerSize',40,'Color',
            '[0.1,0.3,0.8]');
        else
% alpha male
        plot(xpos(j),ypos(j),'.','MarkerSize',40,'Color',
            '[1,0.8,0.4]');

        end
    end
end
%hold off;
text(xpos(:),ypos(:),num2str(gela_nr),'VerticalAlignment',
'bottom','HorizontalAlignment','left','Color','k','FontSize',
14);           %'FontWeight','bold',

```

```

title ( 'GELADA_BABOON_-_PLAYGROUND' );
grid on;
%bg = imread('grassland.jpg'); % Plot image as background
%imagesc(bg);
rectangle('Position',[-spawning_size/2,-spawning_size/2,
spawning_size,spawning_size]);
%text(-0.6,-0.1,int2str(n));
axis([-(field_size/2) (field_size/2) -(field_size/2)
(field_size/2)]); % set field size
hold off;

end

```

Listing 6: function: plotinteraction.m

```

function [ ] = plotinteraction(gela_nr,xpos,ypos,gender,
alpha,spawning_size,field_size,i,nearest,interact_type)

% Plot whole Playground
subplot(1,3,1:2);
plot(xpos(1),ypos(1),'.','MarkerSize',40,'Color','w');
hold on;
for j = 1:length(xpos)
    if (gender(j) == 0 && alpha ~= j)
% females
        plot(xpos(j),ypos(j),'.','MarkerSize',40,'Color',
        '[1,0.4,0.9]');
    else if (gender(j) ~= 0 && alpha ~= j)
% normal males
        plot(xpos(j),ypos(j),'.','MarkerSize',40,'Color',
        '[0.1,0.3,0.8]');
    else
% alpha male
        plot(xpos(j),ypos(j),'.','MarkerSize',40,'Color',
        '[1,0.8,0.4]');
    end
end
end
%hold off;

```



```

text(xpos(:),ypos(:),num2str(gela_nr),'VerticalAlignment',
'bottom','HorizontalAlignment','left','Color','k','FontSize',
14);           %'FontWeight','bold',
title('GELADA_BABOON_PLAYGROUND');
grid on;
%bg = imread('grassland.jpg'); % Plot image as background
%imagesc(bg);
rectangle('Position',[-spawning_size/2,-spawning_size/2,
spawning_size,spawning_size]);
%text(-0.6,-0.1,int2str(n));
axis([-(field_size/2) (field_size/2) -(field_size/2)
(field_size/2)]); % set field size
hold off;

%Mark interacting Geladas with color
% interacting
if interact_type == 0
    hold on;
    plot(xpos(i), ypos(i),'.','MarkerSize',30,
'MarkerEdgeColor','y');
    plot(xpos(nearest), ypos(nearest),'.','MarkerSize',30,
'MarkerEdgeColor','y');
    hold off;

% i wins, nearest_gelada loses
elseif interact_type == 1
    hold on;
    plot(xpos(i), ypos(i),'.','MarkerSize',30,
'MarkerEdgeColor','g');
    plot(xpos(nearest), ypos(nearest),'.','MarkerSize',30,
'MarkerEdgeColor','r');
    hold off;

% nearest wins, i loses
elseif interact_type == 2
    hold on;
    plot(xpos(i), ypos(i),'.','MarkerSize',30,
'MarkerEdgeColor','r');
    plot(xpos(nearest), ypos(nearest),'.','MarkerSize',30,

```

```

        'MarkerEdgeColor','g');
    hold off;

% i grooms nearest
elseif interact_type == 3
    hold on;
    plot(xpos(nearest), ypos(nearest), '.','MarkerSize',30,
        'MarkerEdgeColor',[0.5,0.1,0.9]);
    plot(xpos(i), ypos(i), '.','MarkerSize',30,
        'MarkerEdgeColor',[0.7,0.5,1]);
    hold off;

% nearest grooms i
elseif interact_type == 4
    hold on;
    plot(xpos(i), ypos(i), '.','MarkerSize',30,
        'MarkerEdgeColor',[0.5,0.1,0.9]);
    plot(xpos(nearest), ypos(nearest), '.','MarkerSize',30,
        'MarkerEdgeColor',[0.7,0.5,1]);
    hold off;

% doing a random walk
elseif interact_type == 5
    hold on;
    plot(xpos(i), ypos(i), '.','MarkerSize',30,
        'MarkerEdgeColor','b');
    hold off;

else
%do nothing
end

end

```

Listing 7: function: setminof.m

```

function [ a ] = setminof( a,b )

% set minimum of dominance
if a < b

```

```
a = b;  
end
```

Listing 8: function: x_move_to_individual.m

```
function [ x_i_new ] = x_move_to_individual( x_i , y_i ,  
x_neigh , y_neigh , displace )  
  
%calculate distance btw the two baboons  
dist = norm([x_neigh , y_neigh] - [x_i , y_i]);  
  
%calculate x component of the normalized vector pointing  
%from i to nearest neighbour)  
delta_x = (x_neigh - x_i)/dist;  
  
%calculate x component of move vector(so that i is 'displace'  
%away from neighbour)  
displ_x = delta_x*(dist-displace);  
  
% new x coordinate (old coordinate + displacement)  
x_i_new = x_i + displ_x;  
end
```

Listing 9: function: y_move_to_individual.m

```
function [ y_i_new ] = y_move_to_individual( x_i , y_i ,  
x_neigh , y_neigh , displace )  
  
%calculate distance btw the two baboons  
dist = norm([x_neigh , y_neigh] - [x_i , y_i]);  
  
%calculate y component of the normalized vector pointing  
%from i to nearest neighbour)  
delta_y = (y_neigh - y_i)/dist;  
  
%calculate y component of move vector(so that i is 'displace'  
%away from neighbour)  
displ_y = delta_y*(dist-displace);  
  
%new y coordinate (old coordinate + displacement)  
y_i_new = y_i+displ_y;
```

end