1) Detection and tracking of moving objects

Let us consider a static laser scanner observing a 2D environment. This laser scanner has a field of view of 13 degrees and a resolution of 1 degree (see figure 1). The distances (in centimeters) collected by this sensor are stored in a 1D table. For instance, the 1D table below corresponds to the distance at each beam. We want to use this sensor to detect and track moving objects. The objects move from left to right.

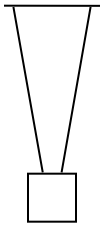

Figure 1

Here, we give the observations on a time interval.

	-6º	-5º	-4º	-3º	-2º	-1º	0º	+1º	+2º	+3º	+4º	+5º	+6º
T = 1	8	8	8	4	4	4	4	6	8	6	9	12	12
T = 2	8	7	8	4	4	4	4	7	8	6	9	12	12
T = 3	3	8	8	4	4	4	4	6	8	5	9	12	12
T = 4	8	8	3	4	4	4	4	6	8	6	9	11	12
T = 5	8	8	8	4	3	4	4	7	8	6	9	12	12
T = 6	8	8	8	4	4	4	3	7	8	6	9	12	12
T = 7	8	8	8	4	4	4	4	7	3	5	9	11	12
T = 8	8	8	8	4	4	4	4	7	8	6	3	12	12
T = 9	8	8	8	4	4	4	4	7	8	6	9	12	3
T = 10	8	8	8	4	4	4	4	6	8	6	9	12	12

table 1: data of laser scanner on a first time interval

Questions

1) Draw the field of view of this lasers canner at time T=1 and T=2.
2) Using the previous set of observations, explain how we can detect moving objects.
3) In table1, we suppose that the laser scanner has observed one moving object. Determine the sequence of positions of this moving object in the sequence of data of the laser scanner. Justify your answer. Estimate the motion of this moving object between 2 instants.

Here, we give the observations on another time interval.

	-6º	-5º	-4º	-3º	-2º	-1º	0º	+1º	+2º	+3º	+4º	+5º	+6º
T = 1	8	8	8	4	4	4	4	6	8	6	9	12	12
T = 2	5	8	8	4	4	4	4	7	8	6	9	12	12
T = 3	4	7	5	4	4	4	4	6	8	5	9	12	12
T = 4	8	8	4	4	4	4	4	6	8	6	9	11	12

T = 5	8	8	8	4	4	4	4	7	8	6	9	12	12
T = 6	8	8	8	4	4	4	4	4	8	5	9	12	12
T = 7	8	8	8	4	4	4	4	7	8	6	4	11	12
T = 8	8	8	8	4	4	4	4	7	8	6	6	12	5
T = 9	8	8	8	4	4	4	4	7	8	6	9	12	12
T = 10	8	8	8	4	4	4	4	7	8	6	9	12	12

table 2: data of the laser scanner of a second time interval

4) In table2, we suppose that the laser scanner has observed two moving objects. Determine the sequence of positions of these two moving objects. Justify your answer. Estimate the motion of each moving object between 2 instants.
5) We know that the motion of each moving object is constant from left to right. The differences of motions that are observed for each moving object are due to errors in detection of the laser scanner. Actually, when a moving object is detected at a given angle, it is located at an angle close to this one. For instance, if a moving object is detected at 1 degree, it could be located at 1 degree but at 0 degree or at 2 degrees as well. Using a Kalman filter, give the real motion of each moving object. Give the parameters of this filter and justify your answer.