

Discrete modeling  
Practice #1  
Prediction of country's population change

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# 1 Task and data

Population is represented by age range and gender based cohorts. For a given country each row in the input demographic data consists of a year and corresponding estimated population of every cohort.

Data Source: United Nations, Population Division, Department of Economic and Social Affairs (2005) World Population Prospects: The 2004 Revision.

Figure 1: Data sample

Sex	Date	0 - 4	5 - 9	10 - 14	15 - 19	20 - 24	25 - 29	30 - 34
Male	1950	5181.317	3742.25	6156.804	4980.353	5558.784	2888.972	2356.78
Male	1955	6486.704	5161.022	3736.718	6138.68	4934.059	5479.23	2838.637
Male	1960	6856.237	6424.928	5122.614	3699.521	6050.614	4834.841	5358.582
Male	1965	6183.219	6791.811	6376.026	5076.026	3639.862	5940.062	4727.974
Male	1970	4767.401	6124.755	6740.4	6319.099	5001.022	3565.128	5815.033
Male	1975	5132.145	4746.438	6032.827	6539.69	6164.026	4895.847	3511.817
Male	1980	5427.115	5118.113	4703.456	5860.15	6673.405	6177.127	5047.496
Male	1985	5925.065	5443.009	5147.636	4761.646	5928.585	6622.575	6084.207
Male	1990	5894.81	5958.961	5473.274	5195.858	4894.869	5973.811	6542.631

The goal of this practice is to come up with a discrete model to forecast the country's demographic profile and population for the next 100 years and compare with existing prediction.

# 2 Model

We came up with the following model.

$$M_{0,4}^{n+1} = \frac{(F_{20,24}^n + F_{25,29}^n + F_{30,34}^n + F_{35,39}^n) \cdot FR}{GR + 1} \quad (1)$$

$$F_{0,4}^{n+1} = \frac{(F_{20,24}^n + F_{25,29}^n + F_{30,34}^n + F_{35,39}^n) \cdot FR \cdot GR}{GR + 1} \quad (2)$$

$$M_{k,k+4}^{n+1} = M_{k-5,k-1}^n * SR_{k-5,k-1}, k \in [5, 10, \dots, 95] \quad (3)$$

$$F_{k,k+4}^{n+1} = F_{k-5,k-1}^n * SR_{k-5,k-1}, k \in [5, 10, \dots, 95] \quad (4)$$

where  $M_{k,k+4}^n$  and  $F_{k,k+4}^n$  are male and female population of age from  $k$  to  $k + 4$  in  $n$ 'th prediction year.  $SR_{k,k+4}$ ,  $FR$ ,  $GR$  - survival, fertility and gender rates respectively - are estimated parameters of the model.

Survival rate of group  $[k, k + 4]$  is an average percentage of group population that is still alive for the next period of time.

Fertility rate is an average annually number of children per women of fertile age (20 - 39).

Gender rate is an average of the last four periods ratio of females to males in a population.

We took the last period estimates in the data as the initial state.

### 3 Prediction results

As we can see from the results below, the constructed model (red line) might be not an exact match but it gives a prediction with close to the prediction by United Nations (green line) main trend. We can only assume that our model uses the same basic principles as UN's one, although it might not take some factors into account (e.g. migration and historical events).







