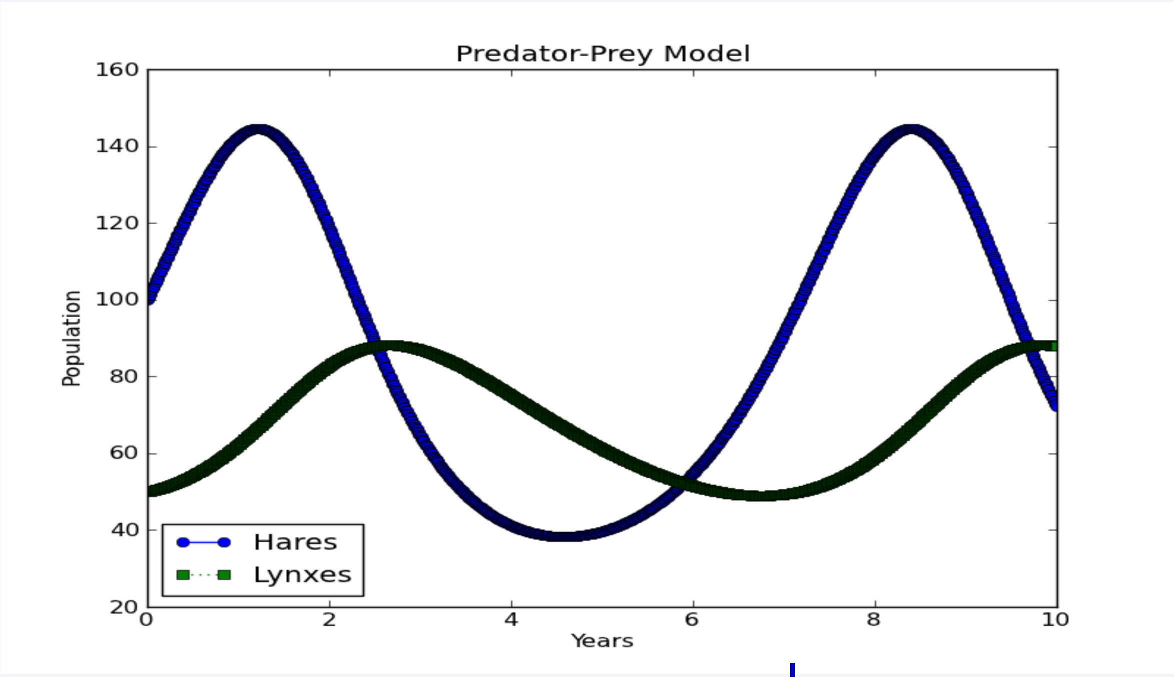
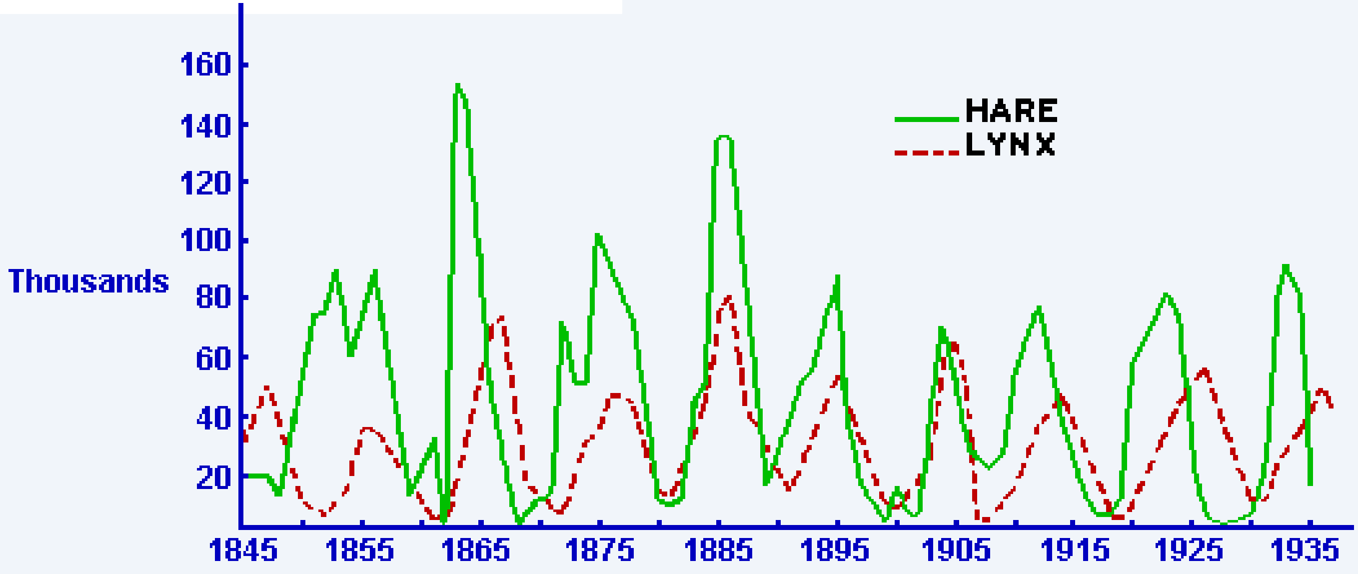
Predicting predator-prey populations

Desired results





Here's an approximation of reality:

The hare birth rate is constant, as their food supply is unlimited. Hares only die when eaten by a lynx, and the number of hares eaten is proportional to how often hares & lynxes meet, i.e., the chance of a lynx catching a hare.

The lynx birth rate is also proportional to how often hares & lynxes meet, i.e., the food available for each lynx family. Lynxes only die from natural causes, and their death rate is constant.

Dr. Siemann, EEB

Lotka & Volterra, 1926

Computational Thinking

Problem description

Abstraction

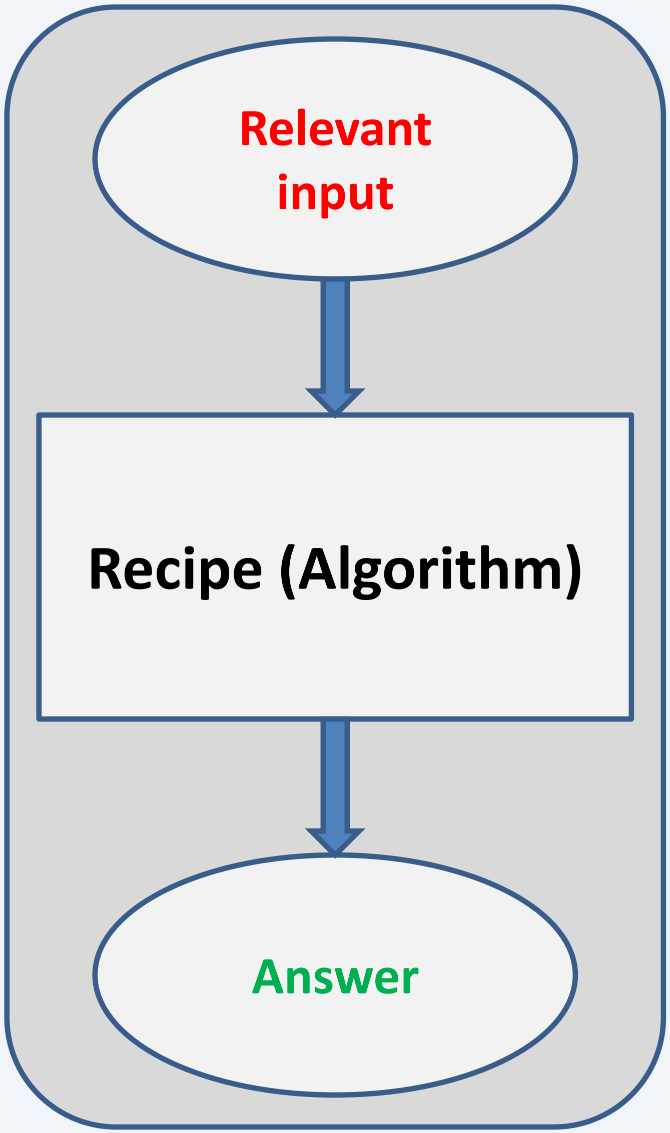
Automation

Computational goal

Information extraction

Algorithm design

Algorithm implementation



Hares' & Lynxes' Populations

Problem description

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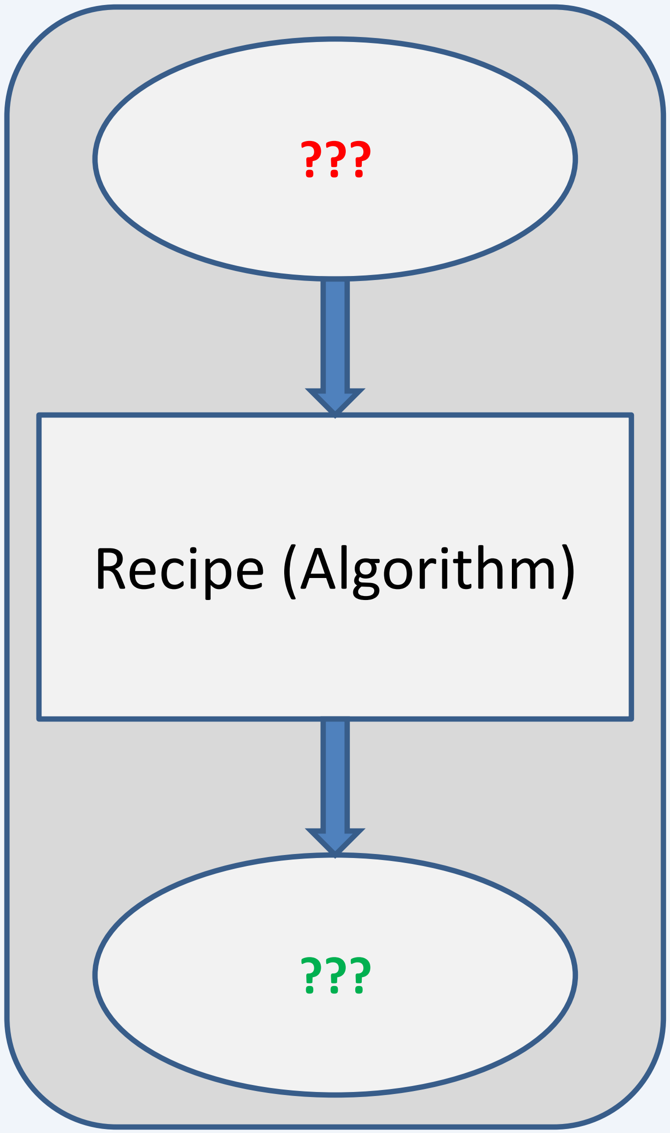

Algorithm Design – Decomposition

1. Generate population data.

   Repeatedly,

   a. Generate next populations of predator & prey.

2. Display population data.

Algorithm Design – Refinement

1. Store original populations.

2. Generate population data.

   Repeatedly,

   a. Generate next populations of predator & prey.
   b. Store new populations.

3. Display stored population data.

The hare birth rate is constant, as their food supply is unlimited. Hares only die when eaten by a lynx, and the number of hares eaten is proportional to how often hares & lynxes meet, i.e., the chance of a lynx catching a hare.

The lynx birth rate is also proportional to how often hares & lynxes meet, i.e., the food available for each lynx family. Lynxes only die from natural causes, and their death rate is constant.

Hare annual pop. change $= h \cdot (hare\_birth - hare\_predation \cdot l)$

Lynx annual pop. change $= l \cdot (lynx\_birth \cdot h - lynx\_death)$

Lotka & Volterra, 1926

$$\text{Hare annual pop. change} = \frac{\Delta h}{\Delta t} = h \cdot (hare\_birth - hare\_predation \cdot l)$$

.4 .003

$$\text{Lynx annual pop. change} = \frac{\Delta l}{\Delta t} = l \cdot (lynx\_birth \cdot h - lynx\_death)$$

.004 .2

	Initially (Year 0)	Year 1	Year 2	Year 3
# Hares	100	125	152	177
Hares born	+ 40	50	61	71
Hares eaten	- 15	23	36	58
# Lynxes	50	60	78	109
Lynxes die	- 10	12	16	22
Lynxes born	+ 20	30	47	77

Rounding all #s.

Algorithm Design – Refinement

Given $h, l, hare\_birth, hare\_predation, lynx\_birth,$ $lynx\_death, years.$

1. Store $(0, h)$ in $hare\_pop$. Store $(0, l)$ in $lynx\_pop$.
2. Repeat for $y = 1, \ldots, years$:
   a. Compute $h, l = h + \frac{\Delta h}{\Delta t}, l + \frac{\Delta l}{\Delta t}$
   b. Add (y, h) to end of $hare\_pop$. Add (y, l) to end of $lynx\_pop$.
3. Plot $hare\_pop$ and $lynx\_pop$.

Suggested Readings

- Predator-prey models
- Lotka-Volterra equation
- Wolves & Moose of Isle Royale
  - Esp. the Data section
  - A technical paper about population cycles