Day 1, exercise 4: Vigilance

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December 22, 2014

Abstract

This article is created within the CAS program Maxima and shows how to do algebraic manipuations and graphical plotting. The output is in LaTeX format.

1 Introduction

When an organism has found the time and suitable location to forage, it faces a trade-off: looking down to search for prey, or looking up, to search for predators. Using simple equations, the optimum strategy for a solitary individual is calculated.

2 Exercise

First, we write down all equations (for definitions see table 1 on page 1).

symbol	description
v	fraction of foraging time invested in being watchful
$S(v)$	survival probability
$F(v)$	foraging efficiency
$W(v)$	fitness

Table 1: Definitions

$$S\left(v\right) = v$$

$$F\left(v\right) = 1.0 - v^2$$

$$W\left(v\right) = -v^2 + v + 1.0$$

The fitness function plotted is plotted in figure 1 on page 2.

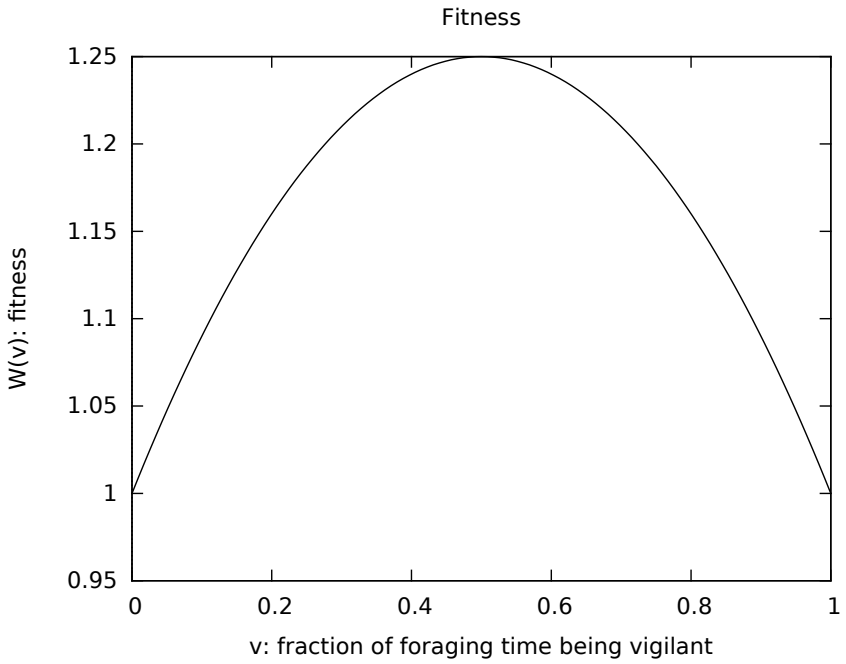

Figure 1: Fitness function

To calculate the maximum or minimum, set the derivate to zero and solve it:

$$\frac{d}{d\,v}\,W\,(v) = 1 - 2\,v = 0$$

$$v = \frac{1}{2}$$

Thus, the optimal vigilance level v equals:

$$\frac{1}{2}$$

This optimal vigilance level results in a fitness of:

$$W\left(\frac{1}{2}\right) = 1.25$$

To find out if it is a fitness minimum or maximum, calculate the second derivative and find out its value at the minimum or maximum:

$$\frac{d^2}{d\,v^2}\,W\,(v) = -2$$

Thus, this value being below zero, it is a maximum.

A Script file

```
#!/bin/bash
maxima_input_file="Day1_4_vigilance.txt"
tex_output_file="Day1_4_vigilance_output.tex"

if [ -e $tex_output_file ]
then
  rm $tex_output_file
fi

maxima -b $maxima_input_file
pdflatex $tex_output_file
#Do this twice, so pdflatex can fill in the references
pdflatex $tex_output_file
```

B Maxima file

```
/* Maxima batch file */

/* Load libraries */
load("stringproc")$

/* Input filename */
bash_filename:"Day1_4_vigilance.sh"$
maxima_filename:"Day1_4_vigilance.txt"$ /* this file */

/* Output filenames */
tex_filename:"Day1_4_vigilance_output.tex"$
pdf_filename:"/home/richel/GitHubs/Maxima/
    Day1_4_vigilance_output.pdf"$

/* Write results to TeX file */
stream: openw(tex_filename)$

printf(stream,"\\documentclass{article}~%")$
printf(stream,"~%")$
printf(stream,"\\usepackage{listings}~%")$
printf(stream,"\\usepackage{graphicx}~%")$
printf(stream,"~%")$
printf(stream,"\\title{Day 1, exercise 4: Vigilance}~%")$
printf(stream,"\\author{Richel Bilderbeek}~%")$
printf(stream,"\\date{\\today}~%")$
printf(stream,"~%")$
```

```
printf(stream,"\\begin{document}~%")$
printf(stream,"~%")$
printf(stream,"\\maketitle~%")$
printf(stream,"~%")$
printf(stream,"\\begin{abstract}~%")$
printf(stream,"This article is created within the CAS
   program Maxima~%")$
printf(stream,"and shows how to do algebraic manipuations
    and graphical plotting.~%")$
printf(stream,"The output is in \\LaTeX~~ format.~%")$
printf(stream,"\\end{abstract}~%")$
printf(stream,"~%")$
printf(stream,"\\section{Introduction}~%")$
printf(stream,"~%")$
printf(stream,"When an organism has found the time and
   suitable location to forage, it faces a trade-off:~%")
   $
printf(stream,"looking down to search for prey, or
   looking up, to search for predators. Using simple~%")$
printf(stream,"equations, the optimum strategy for a
   solitary individual is calculated.~%")$
printf(stream,"~%")$
printf(stream,"\\section{Exercise}~%")$
printf(stream,"First, we write down all equations~%")$
printf(stream,"(for definitions see table \\ref{table:
   table_definition} on page \\pageref{table:
   table_definition}).~%")$
printf(stream,"~%")$
printf(stream,"\\begin{table}[here]~%")$
printf(stream,"  \\centering~%")$
printf(stream,"  \\begin{tabular}{ | r | l | }~%")$
printf(stream,"    \\hline~%")$
printf(stream,"    symbol & description \\\\~%")$
printf(stream,"    \\hline~%")$
printf(stream,"    $v$ & fraction of foraging time
   invested in being watchful \\\\~%")$
printf(stream,"    $S(v)$ & survival probability \\\\~%")
   $
printf(stream,"    $F(v)$ & foraging efficiency \\\\~%")$
printf(stream,"    $W(v)$ & fitness \\\\~%")$
printf(stream,"    \\hline~%")$
printf(stream,"  \\end{tabular}~%")$
printf(stream,"  \\caption{Definitions}~%")$
printf(stream,"  \\label{table:table_definition}~%")$
printf(stream,"\\end{table}~%")$
printf(stream,"~%")$
```

```
Survival(v) := S(v) = v;

printf(stream,tex(Survival(v),false))$
printf(stream,"~%")$

Foraging(v) := F(v) = 1.0 - (v^2);

printf(stream,tex(Foraging(v),false))$
printf(stream,"~%")$

Fitness(v) := W(v) = ''(rhs(Survival(v)) + rhs(Foraging(v
    )));

printf(stream,tex(Fitness(v),false))$
printf(stream,"~%")$
printf(stream,"The fitness function plotted is plotted in
     figure ~%")$
printf(stream,"\\ref{figure:figure_fitness} on page \\
    pageref{figure:figure_fitness}.\\\\~%")$
printf(stream,"~%")$

plot2d(
  rhs(Fitness(v)),[v,0.0,1.0],
  [title,"Fitness"],
  [xlabel,"v: fraction of foraging time being vigilant"],
  [ylabel,"W(v): fitness"],
  [color,black],
  [pdf_file,pdf_filename]
);

printf(stream,"\\begin{figure}[here]~%")$
printf(stream,"\\includegraphics[width=1\\textwidth]{")$
printf(stream,pdf_filename)$
printf(stream,"}\\\\\\\\\~%")$
printf(stream,"  \\caption{Fitness function}~%")$
printf(stream,"  \\label{figure:figure_fitness}~%")$
printf(stream,"\\end{figure}~%")$
printf(stream,"~%")$
printf(stream,"To calculate the maximum or minimum, set
    the derivate to zero and solve it:~%")$

FitnessDeriv(v) := diff(W(v),v) = ''(diff(rhs(Fitness(v))
    ,v));
```

```
maximum:solve(rhs(FitnessDeriv(v))=0)[1];

printf(stream,tex(FitnessDeriv(v)=0,false))$
printf(stream,tex(maximum,false))$
printf(stream,"~%")$

printf(stream,"Thus, the optimal vigilance level $v$
    equals:")$
printf(stream,tex(rhs(maximum),false))$
printf(stream,"~%")$

printf(stream,"This optimal vigilance level results in a
    fitness of:")$
printf(stream,tex(Fitness(rhs(maximum)),false))$
printf(stream,"~%")$

printf(stream,"To find out if it is a fitness minimum or
    maximum,~%")$
printf(stream,"calculate the second derivative~%")$
printf(stream,"and find out its value at the minimum or
    maximum:~%")$
printf(stream,"~%")$

FitnessDerivDeriv(v) := diff(W(v),v,2) = ''(diff(rhs(
    FitnessDeriv(v)),v));

printf(stream,tex(FitnessDerivDeriv(v),false))$

if rhs(FitnessDerivDeriv(v))<0
then
  printf(stream,"Thus, this value being below zero, it is
      a maximum.~%")
else
  printf(stream,"Thus, this value being above zero, it is
      a minimum.~%")
;
printf(stream,"~%")$
printf(stream,"\\appendix~%")$
printf(stream,"~%")$
printf(stream,"\\section{Script file}~%")$
printf(stream,"~%")$
printf(stream,"\\lstinputlisting[language=C++,
    showstringspaces=false,breaklines=true,frame=single]{"
    )$
printf(stream,bash_filename)$
printf(stream,"}~%")$
```

```
printf(stream,"~%")$
printf(stream,"\\section{Maxima file}~%")$
printf(stream,"~%")$
printf(stream,"\\lstinputlisting[language=C++,
    showstringspaces=false,breaklines=true,frame=single]{"
    )$
printf(stream,maxima_filename)$
printf(stream,"}~%")$
printf(stream,"~%")$
printf(stream,"\\section{\\LaTeX~~file}~%")$
printf(stream,"~%")$
printf(stream,"\\lstinputlisting[language=tex,
    showstringspaces=false,breaklines=true,frame=single]{"
    )$
printf(stream,tex_filename)$
printf(stream,"}~%")$
printf(stream,"~%")$
printf(stream,"\\end{document}~%")$
close(stream)$
```

C LaTeX file

```
\documentclass{article}

\usepackage{listings}
\usepackage{graphicx}

\title{Day 1, exercise 4: Vigilance}
\author{Richel Bilderbeek}
\date{\today}

\begin{document}

\maketitle

\begin{abstract}
This article is created within the CAS program Maxima
and shows how to do algebraic manipuations and graphical
    plotting.
The output is in \LaTeX~ format.
\end{abstract}

\section{Introduction}
```

```
When an organism has found the time and suitable location
    to forage, it faces a trade-off:
looking down to search for prey, or looking up, to search
    for predators. Using simple
equations, the optimum strategy for a solitary individual
    is calculated.

\section{Exercise}
First, we write down all equations
(for definitions see table \ref{table:table_definition}
   on page \pageref{table:table_definition}).

\begin{table}[here]
  \centering
  \begin{tabular}{ | r | l | }
    \hline
    symbol & description \\
    \hline
    $v$ & fraction of foraging time invested in being
       watchful \\
    $S(v)$ & survival probability \\
    $F(v)$ & foraging efficiency \\
    $W(v)$ & fitness \\
    \hline
  \end{tabular}
  \caption{Definitions}
  \label{table:table_definition}
\end{table}

$$S\left(v\right)=v$$

$$F\left(v\right)=1.0-v^2$$

$$W\left(v\right)=-v^2+v+1.0$$

The fitness function plotted is plotted in figure
\ref{figure:figure_fitness} on page \pageref{figure:
    figure_fitness}.\\

\begin{figure}[here]
\includegraphics[width=1\textwidth]{/home/richel/GitHubs/
    Maxima/Day1_4_vigilance_output.pdf}\\\\
  \caption{Fitness function}
  \label{figure:figure_fitness}
\end{figure}
```

```
To calculate the maximum or minimum, set the derivate to
    zero and solve it:
$${{d}\over{d\,v}}\,W\left(v\right)=1-2\,v=0$$
$$v={{1}\over{2}}$$

Thus, the optimal vigilance level $v$ equals:$${{1}\over
    {2}}$$

This optimal vigilance level results in a fitness of:$$W\
    left({{1}\over{2}}\right)=1.25$$

To find out if it is a fitness minimum or maximum,
calculate the second derivative
and find out its value at the minimum or maximum:

$${{d^2}\over{d\,v^2}}\,W\left(v\right)=-2$$
Thus, this value being below zero, it is a maximum.

\appendix

\section{Script file}

\lstinputlisting[language=C++,showstringspaces=false,
    breaklines=true,frame=single]{Day1_4_vigilance.sh}

\section{Maxima file}

\lstinputlisting[language=C++,showstringspaces=false,
    breaklines=true,frame=single]{Day1_4_vigilance.txt}

\section{\LaTeX~file}

\lstinputlisting[language=tex,showstringspaces=false,
    breaklines=true,frame=single]{Day1_4_vigilance_output.
    tex}

\end{document}
```