Case 2000 page 69 exercise

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Abstract

This article is created within the CAS program Maxima and shows how to the exercise of [1] at page 69.

1 Introduction

LaTeX is commonly used for writing publishable scientific articles[2]. Algebraic manipulations can be done by a CAS, for example Maxima, Maple or Mathematica. Maxima is the only free and open-source program, and it is the oldest free and open-source computer algebra system, with development started in 1967 (as Macsyma) or 1982 (as MAXIMA). This article is an example of writing a LaTeX article within Maxima

2 Exercise

symbol	description
I	Indentity matrix
L	Leslie matrix
M	Leslie matrix with λ subtracted at diagonal
x	population density vector
Z	Vector filled with zeroes
λ	population growth rate

Table 1: Definitions

The equations to solve are:

$$x\,L = x\,\lambda \tag{1}$$

$$x\,M = Z \tag{2}$$

Equation 1 equals equation 3.21 of [1] Equation 2 equals equation 3.23 of [1] (for definitions see table 1 on page 1). The Leslie matrix, L, given in this exercise is:

$$L = \begin{pmatrix} 1.0 & 1.0 \\ 0.8 & 0.8 \end{pmatrix} \quad (3)$$

The Leslie matrix, L, used:

$$L = \begin{pmatrix} 0.1 & 2.0 \\ 0.1 & 0.8 \end{pmatrix} \quad (4)$$

Note that this matrix has 2 age classes. The simplifies equation 1 to:

$$\begin{pmatrix} 0.1\,x & 2.0\,x \\ 0.1\,x & 0.8\,x \end{pmatrix} = x\,\lambda \quad (5)$$

Solving equation 1 can be done with equation 6:

$$det(L - \lambda * I) = Z \quad (6)$$

Equation 6 equals equation 3.24 of [1], where I is the identity matrix:

$$I = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \quad (7)$$

And Z is the vector of zeroes:

$$Z = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \quad (8)$$

This simplifies equation 6 to:

$$det\left(\begin{pmatrix} 0.1 - \lambda & 2.0 \\ 0.1 & 0.8 - \lambda \end{pmatrix}\right) = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \quad (9)$$

The determinant of that matrix (M), is:

$$det(\begin{pmatrix} 0.1 - \lambda & 2.0 \\ 0.1 & 0.8 - \lambda \end{pmatrix}) = (0.1 - \lambda)\ (0.8 - \lambda) - 0.2 \quad (10)$$

Solving $M = 0$, the λs found are:

$$\left[\lambda = -\frac{\sqrt{129} - 9}{20}, \lambda = \frac{\sqrt{129} + 9}{20}\right] \quad (11)$$

There is one stable population structure, $\lambda = 0$, which is denotes an extinct population. Here I focus on the more interesting value, where $\lambda = -(sqrt(129) - 9)/20$. This lambda is called the dominant eigenvalue, which equals the ultimate population growth.

Put λ in M, this results in:

$$M = \begin{pmatrix} \frac{\sqrt{129}-9}{20} + 0.1 & 2.0 \\ 0.1 & \frac{\sqrt{129}-9}{20} + 0.8 \end{pmatrix} \quad (12)$$

Now we can solve the x of equation 2 (equals 3.23 from [1]), which was this:

$$x\,M = Z \tag{13}$$

This equation is unsolvable, unless we assign a value to an element of x. Here, I put 1.0 as the initial value of x its first element. (it will be rescaled later):

$$x = \begin{pmatrix} 1.0 \\ x_2 \end{pmatrix} \tag{14}$$

Putting this x in equation 2:

$$M * x = \begin{pmatrix} 2.0\,x_2 + 1.0\,\left(\frac{\sqrt{129}-9}{20} + 0.1\right) \\ \left(\frac{\sqrt{129}-9}{20} + 0.8\right)\,x_2 + 0.1 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \tag{15}$$

As our matrix has two rows, there are two equations that can be solved: Solving the upper, results in $x2 = -(sqrt(129) - 7)/40$. This results in an x of:

$$x = \begin{pmatrix} 1.0 \\ -\frac{\sqrt{129}-7}{40} \end{pmatrix} \tag{16}$$

x must be rescaled so that its sum equals 1.0. x its current sum is $1.0 - (sqrt(129) - 7)/40$, so dividing all elements by it, results in an x of:

$$x = \begin{pmatrix} \frac{1.0}{1.0-\frac{\sqrt{129}-7}{40}} \\ -\frac{\sqrt{129}-7}{40\left(1.0-\frac{\sqrt{129}-7}{40}\right)} \end{pmatrix} \tag{17}$$

3 Conclusion

For this Leslie matrix:

$$\begin{pmatrix} 0.1 & 2.0 \\ 0.1 & 0.8 \end{pmatrix} \tag{18}$$

The dominant eigenvalue, λ, is:

$$\lambda = -(sqrt(129) - 9)/20 \tag{19}$$

The stable population size distribution is:

$$x = \begin{pmatrix} \frac{1.0}{1.0-\frac{\sqrt{129}-7}{40}} \\ -\frac{\sqrt{129}-7}{40\left(1.0-\frac{\sqrt{129}-7}{40}\right)} \end{pmatrix} \tag{20}$$

4 Discussion

Writing LaTeX within Maxima can be done, but it is a bit cumbersome: Maxima does not know LaTeX syntax and just creates contextless strings, which might not be compilable by LaTeX. However, because the script does create a .tex file, this file can be inspected easily with a LaTeX tool like texmaker.

References

[1] Case, Ted J. 2000 An illustrated guide to theoretical ecology.

[2] Gaudeul, A. 2006 Do Open Source Developers Respond to Competition?: The (La)TeX Case Study. Available at SSRN: http://ssrn.com/abstract=908946 or http://dx.doi.org/10.2139/ssrn.908946

A Script file

```
#!/bin/bash
maxima_input_file="case_2000_69.txt"
tex_output_file="case_2000_69_output.tex"

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

maxima -b $maxima_input_file
pdflatex $tex_output_file
pdflatex $tex_output_file
```

B Maxima file

```
/* Maxima batch file */

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

/* Input filename */
bash_filename:"case_2000_69.sh"$
maxima_filename:"case_2000_69.txt"$ /* this file */

/* Output filenames */
tex_filename:"case_2000_69_output.tex"$
```

```
/* 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{Case 2000 page 69 exercise}~%")$
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 the exercise of \\cite{
   case2000} at page 69.~%")$
printf(stream,"\\end{abstract}~%")$
printf(stream,"~%")$
printf(stream,"\\section{Introduction}~%")$
printf(stream,"~%")$
printf(stream,"\\LaTeX~~is commonly used for writing
   publishable scientific articles\\cite{gaudeul2006}.~%"
   )$
printf(stream,"Algebraic manipulations can be done by a
   CAS, for example Maxima, Maple or Mathematica.~%")$
printf(stream,"Maxima is the only free and open-source
   program, and it is the oldest free and open-source
   computer algebra system, with development started in
   1967 (as Macsyma) or 1982 (as MAXIMA).~%")$
printf(stream,"This article is an example of writing a \\
   LaTeX~~ article within Maxima~%")$
printf(stream,"~%")$
printf(stream,"\\section{Exercise}~%")$
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,"    $I$ & Indentity matrix \\\\~%")$
```

```
printf(stream,"    $L$ & Leslie matrix \\\\~%")$
printf(stream,"    $M$ & Leslie matrix with $\\lambda$
   subtracted at diagonal \\\\~%")$
printf(stream,"    $x$ & population density vector \\\\~%
   ")$
printf(stream,"    $Z$ & Vector filled with zeroes \\\\~%
   ")$
printf(stream,"    $\\lambda$ & population growth rate
   \\\\~%")$
printf(stream,"    \\hline~%")$
printf(stream,"  \\end{tabular}~%")$
printf(stream,"  \\caption{Definitions}~%")$
printf(stream,"  \\label{table:table_definition}~%")$
printf(stream,"\\end{table}~%")$
printf(stream,"~%")$
printf(stream,"The equations to solve are:~%")$

Eq3_21(L,x,lambda) := L * x = lambda * x;

printf(stream,"\\begin{equation}~%")$
printf(stream,tex1(Eq3_21(L,x,lambda)))$ /* Use tex1
   instead of tex(...,false) for non $$-enclosed output
   */
printf(stream,"\\label{eq:eq3_21}~%")$
printf(stream,"\\end{equation}~%")$

Eq3_23(M,x,Z) := M * x = Z;
Eq3_23_str:tex1(Eq3_23(M,x,Z));

printf(stream,"\\begin{equation}~%")$
printf(stream,tex1(Eq3_23(M,x,Z)))$ /* Use tex1 instead
   of tex(...,false) for non $$-enclosed output */
printf(stream,"\\label{eq:eq3_23}~%")$
printf(stream,"\\end{equation}~%")$

printf(stream,"~%")$
printf(stream,"Equation \\ref{eq:eq3_21} equals equation
   3.21 of \\cite{case2000}~%")$
printf(stream,"Equation \\ref{eq:eq3_23} equals equation
   3.23 of \\cite{case2000}~%")$
printf(stream,"(for definitions see table \\ref{table:
   table_definition} on page \\pageref{table:
   table_definition}).~%")$
printf(stream,"The Leslie matrix, L,  given in this
   exercise is:~%")$
printf(stream,"~%")$
```

```
L_original:matrix([1.0,1.0],[0.8,0.8]);

printf(stream,"\\begin{equation}~%")$
printf(stream,"L=")$
printf(stream,tex1(L_original))$
printf(stream,"\\end{equation}~%")$
printf(stream,"~%")$

L:L_original;
L:matrix([0.1,2.0],[0.1,0.8]);
/* L:matrix([0.1,1.0,0.0],[0.8,0.8,0.0],[0.8,0.8,0.0]);
   */

printf(stream,"The Leslie matrix, L, used:~%")$
printf(stream,"~%")$
printf(stream,"\\begin{equation}~%")$
printf(stream,"L=")$
printf(stream,tex1(L))$
printf(stream,"\\end{equation}~%")$
printf(stream,"~%")$

n_age_classes:matrix_size(L)[1];

printf(stream,"~%")$
printf(stream,"Note that this matrix has ")$
printf(stream,string(n_age_classes))$
printf(stream," age classes.~%")$
printf(stream,"The simplifies equation \\ref{eq:eq3_21}
   to:~%")$
printf(stream,"~%")$
printf(stream,"\\begin{equation}~%")$
printf(stream,tex1(Eq3_21(L,x,lambda)))$
printf(stream,"\\end{equation}~%")$
printf(stream,"~%")$
printf(stream,"Solving equation \\ref{eq:eq3_21} can be
   done with equation \\ref{eq:eq3_24}:~%")$
printf(stream,"~%")$
printf(stream,"\\begin{equation}~%")$
printf(stream,"det(L - \\lambda*I) = Z~%")$
printf(stream,"\\label{eq:eq3_24}~%")$
printf(stream,"\\end{equation}~%")$
printf(stream,"~%")$

I:ident(n_age_classes);
Z:zeromatrix(n_age_classes,1);
```

```
printf(stream,"Equation \\ref{eq:eq3_24} equals equation
    3.24 of \\cite{case2000},~%")$
printf(stream,"where I is the identity matrix:~%")$
printf(stream,"\\begin{equation}~%")$
printf(stream,"I=")$
printf(stream,tex1(I))$
printf(stream,"\\end{equation}~%")$
printf(stream,"And Z is the vector of zeroes:~%")$
printf(stream,"\\begin{equation}~%")$
printf(stream,"Z=")$
printf(stream,tex1(Z))$
printf(stream,"\\end{equation}~%")$
printf(stream,"~%")$

Eq3_24(L,lambda,I,Z) := det(L - lambda * I) = Z;

printf(stream,"This simplifies equation \\ref{eq:eq3_24}
    to:~%")$
printf(stream,"~%")$
printf(stream,"\\begin{equation}~%")$
printf(stream,tex1(Eq3_24(L,lambda,I,Z)))$
printf(stream,"\\end{equation}~%")$
printf(stream,"~%")$

/* Great that M is in Eq3_24_b, but I cannot get it out,
    so I do it manually*/
M:copymatrix(L);
D: diagmatrix (n_age_classes, lambda);
M:M-D;

printf(stream,"~%")$
printf(stream,"The determinant of that matrix ($M$), is
    :~%")$
printf(stream,"\\begin{equation}~%")$
printf(stream,"det(")$
printf(stream,tex1(M))$
printf(stream,")=")$
printf(stream,tex1(determinant(M)))$
printf(stream,"\\end{equation}~%")$
printf(stream,"~%")$

stable_lambdas : solve(determinant(M) = 0,lambda);

printf(stream,"~%")$
```

```
printf(stream,"Solving $M=0$, the $\\lambda$s found are
    :~%")$
printf(stream,"~%")$
printf(stream,"\\begin{equation}~%")$
printf(stream,tex1(stable_lambdas))$
printf(stream,"\\end{equation}~%")$
printf(stream,"~%")$
printf(stream,"There is one stable population structure,
    $\\lambda=0$, which is~%")$
printf(stream,"denotes an extinct population.~%")$

lambda:rhs(stable_lambdas[1]);

printf(stream,"Here I focus on the more interesting value
    ,~%")$
printf(stream,"where $\\lambda=")$
printf(stream,string(lambda))$ /* Don't forget the string
     function */
printf(stream,"$.~%")$
printf(stream,"This lambda is called the dominant
    eigenvalue, which equals the ultimate population
    growth.~%")$
printf(stream,"~%")$

M:''(M); /* Filling it in */

printf(stream,"Put $\\lambda$ in M, this results in:~%")$
printf(stream,"\\begin{equation}~%")$
printf(stream,"M=")$
printf(stream,tex1(M))$
printf(stream,"\\end{equation}~%")$
printf(stream,"~%")$



printf(stream,"Now we can solve the $x$ of equation \\ref
    {eq:eq3_23} (equals 3.23 from \\cite{case2000}),~%")$
printf(stream,"which was this:~%")$
printf(stream,"~%")$
printf(stream,"\\begin{equation}~%")$
printf(stream,Eq3_23_str)$
printf(stream,"\\end{equation}~%")$
printf(stream,"~%")$
printf(stream,"This equation is unsolvable, unless we
    assign a value to an element of $x$.~%")$
printf(stream,"Here, I put $1.0$ as the initial value of
    $x$ its first element.~%")$
```

```
printf(stream,"(it will be rescaled later):~%")$
printf(stream,"~%")$


x:transpose(matrix([1.0,x2]));

if n_age_classes=3
then
  x:transpose(matrix([1.0,x2,x3]))
;

if n_age_classes=4
then
  printf(stream,"NOT SUPPORTED 4 AGE CLASSES YET!~%")
;


printf(stream,"\\begin{equation}~%")$
printf(stream,"x = ")$
printf(stream,tex1(x))$
printf(stream,"\\end{equation}~%")$

EqSolve(M,x,Z):= M.x = Z;

printf(stream,"Putting this $x$ in equation \\ref{eq:
    eq3_23}:~%")$
printf(stream,"\\begin{equation}~%")$
printf(stream,"M * x = ")$
printf(stream,tex1(lhs(EqSolve(M,x,Z))))$
printf(stream,"= ")$
printf(stream,tex1(Z))$
printf(stream,"\\end{equation}~%")$
printf(stream,"As our matrix has two rows, there are two
    equations that can be solved:~%")$

q:''(M.x)[1,1];
x2:rhs(solve(q)[1]);

printf(stream,"Solving the upper, results in $x2=")$
printf(stream,string(x2))$
printf(stream,"$.~%")$
printf(stream,"This results in an $x$ of:~%")$

x;
x:''(x);
```

```
printf(stream,"\\begin{equation}~%")$
printf(stream,"x = ")$
printf(stream,tex1(x))$
printf(stream,"\\end{equation}~%")$
printf(stream,"$x$ must be rescaled so that its sum equals $1.0$.~%")$

sz: matrix_size(x);
my_sum: sum(sum(x[i,j],i,1,sz[1]),j,1,sz[2]);

printf(stream,"$x$ its current sum is $")$
printf(stream,string(my_sum))$
printf(stream,"$, so dividing all elements by it, results in an $x$ of:~%")$

x:x/my_sum;
x;

printf(stream,"\\begin{equation}~%")$
printf(stream,"x = ")$
printf(stream,tex1(x))$
printf(stream,"\\end{equation}~%")$

/* Conclusion */

printf(stream,"\\section{Conclusion}~%")$
printf(stream,"~%")$
printf(stream,"For this Leslie matrix:~%")$
printf(stream,"\\begin{equation}~%")$
printf(stream,tex1(L))$
printf(stream,"\\end{equation}~%")$
printf(stream,"~%")$
printf(stream,"The dominant eigenvalue, $\\lambda$, is:~%")$
printf(stream,"\\\\\\\\~%")$
printf(stream,"\\begin{equation}~%")$
printf(stream,"\\lambda = ")$
printf(stream,string(lambda))$ /* Don't forget the string function */
printf(stream,"\\end{equation}~%")$
printf(stream,"\\\\~%")$
printf(stream,"~%")$
printf(stream,"The stable population size distribution is:~%")$
printf(stream,"~%")$
printf(stream,"\\begin{equation}~%")$
```

```
printf(stream,"x = ")$
printf(stream,tex1(x))$
printf(stream,"\\end{equation}~%")$
printf(stream,"~%")$

/* Discussion */

printf(stream,"\\section{Discussion}~%")$
printf(stream,"~%")$
printf(stream,"Writing \\LaTeX~~within Maxima can be done
    , but it is a bit cumbersome:~%")$
printf(stream,"Maxima does not know \\LaTeX~~syntax and
    just creates contextless strings,~%")$
printf(stream,"which might not be compilable by \\LaTeX
    .~%")$
printf(stream,"However, because the script does create a
    .tex file,~%")$
printf(stream,"this file can be inspected easily with a
    \\LaTeX~~tool like texmaker.~%")$
printf(stream,"~%")$

/* Bibliography */

printf(stream,"\\begin{thebibliography}{9}~%")$
printf(stream,"~%")$
printf(stream,"\\bibitem{case2000}~%")$
printf(stream,"  Case, Ted J.~%")$
printf(stream,"  2000~%")$
printf(stream,"  An illustrated guide to theoretical
    ecology.~%")$
printf(stream,"~%")$
printf(stream,"\\bibitem{gaudeul2006}~%")$
printf(stream,"  Gaudeul, A.~%")$
printf(stream,"  2006~%")$
printf(stream,"  Do Open Source Developers Respond to
    Competition?: The (La)TeX Case Study.~%")$
printf(stream,"  Available at SSRN: http://ssrn.com/
    abstract=908946 or http://dx.doi.org/10.2139/ssrn
    .908946~%")$
printf(stream,"~%")$
printf(stream,"\\end{thebibliography}~%")$
printf(stream,"~%")$

/* Appendix */

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{Case 2000 page 69 exercise}
\author{Richel Bilderbeek}
\date{\today}

\begin{document}

\maketitle

\begin{abstract}
```

```
This article is created within the CAS program Maxima
and shows how to the exercise of \cite{case2000} at page
    69.
\end{abstract}

\section{Introduction}

\LaTeX~is commonly used for writing publishable
    scientific articles\cite{gaudeul2006}.
Algebraic manipulations can be done by a CAS, for example
    Maxima, Maple or Mathematica.
Maxima is the only free and open-source program, and it
    is the oldest free and open-source computer algebra
    system, with development started in 1967 (as Macsyma)
    or 1982 (as MAXIMA).
This article is an example of writing a \LaTeX~ article
    within Maxima

\section{Exercise}

\begin{table}[here]
  \centering
  \begin{tabular}{ | r | l | }
    \hline
    symbol & description \\
    \hline
    $I$ & Indentity matrix \\
    $L$ & Leslie matrix \\
    $M$ & Leslie matrix with $\lambda$ subtracted at
        diagonal \\
    $x$ & population density vector \\
    $Z$ & Vector filled with zeroes \\
    $\lambda$ & population growth rate \\
    \hline
  \end{tabular}
  \caption{Definitions}
  \label{table:table_definition}
\end{table}

The equations to solve are:
\begin{equation}
x\,L=x\,\lambda\label{eq:eq3_21}
\end{equation}
\begin{equation}
x\,M=Z\label{eq:eq3_23}
\end{equation}
```

```
Equation \ref{eq:eq3_21} equals equation 3.21 of \cite{
    case2000}
Equation \ref{eq:eq3_23} equals equation 3.23 of \cite{
    case2000}
(for definitions see table \ref{table:table_definition}
    on page \pageref{table:table_definition}).
The Leslie matrix, L,  given in this exercise is:

\begin{equation}
L=\pmatrix{1.0&1.0\cr 0.8&0.8\cr }\end{equation}

The Leslie matrix, L, used:

\begin{equation}
L=\pmatrix{0.1&2.0\cr 0.1&0.8\cr }\end{equation}


Note that this matrix has 2 age classes.
The simplifies equation \ref{eq:eq3_21} to:

\begin{equation}
\pmatrix{0.1\,x&2.0\,x\cr 0.1\,x&0.8\,x\cr }=x\,\lambda\
    end{equation}

Solving equation \ref{eq:eq3_21} can be done with
    equation \ref{eq:eq3_24}:

\begin{equation}
det(L - \lambda*I) = Z
\label{eq:eq3_24}
\end{equation}

Equation \ref{eq:eq3_24} equals equation 3.24 of \cite{
    case2000},
where I is the identity matrix:
\begin{equation}
I=\pmatrix{1&0\cr 0&1\cr }\end{equation}
And Z is the vector of zeroes:
\begin{equation}
Z=\pmatrix{0\cr 0\cr }\end{equation}

This simplifies equation \ref{eq:eq3_24} to:

\begin{equation}
```

```
{\it det}\left(\pmatrix{0.1-\lambda&2.0\cr 0.1&0.8-\
    lambda\cr }\right)=\pmatrix{0\cr 0\cr }\end{equation}


The determinant of that matrix ($M$), is:
\begin{equation}
det(\pmatrix{0.1-\lambda&2.0\cr 0.1&0.8-\lambda\cr })=\
    left(0.1-\lambda\right)\,\left(0.8-\lambda\right)-0.2\
    end{equation}


Solving $M=0$, the $\lambda$s found are:

\begin{equation}
\left[ \lambda=-{{\sqrt{129}-9}\over{20}} , \lambda={{\
    sqrt{129}+9}\over{20}} \right] \end{equation}

There is one stable population structure, $\lambda=0$,
    which is
denotes an extinct population.
Here I focus on the more interesting value,
where $\lambda=-(sqrt(129)-9)/20$.
This lambda is called the dominant eigenvalue, which
    equals the ultimate population growth.

Put $\lambda$ in M, this results in:
\begin{equation}
M=\pmatrix{{{\sqrt{129}-9}\over{20}}+0.1&2.0\cr 0.1&{{\
    sqrt{129}-9}\over{20}}+0.8\cr }\end{equation}

Now we can solve the $x$ of equation \ref{eq:eq3_23} (
    equals 3.23 from \cite{case2000}),
which was this:

\begin{equation}
x\,M=Z\end{equation}

This equation is unsolvable, unless we assign a value to
    an element of $x$.
Here, I put $1.0$ as the initial value of $x$ its first
    element.
(it will be rescaled later):

\begin{equation}
x = \pmatrix{1.0\cr {\it x_2}\cr }\end{equation}
Putting this $x$ in equation \ref{eq:eq3_23}:
```

```
\begin{equation}
M * x = \pmatrix{2.0\,{\it x_2}+1.0\,\left({{\sqrt
    {129}-9}\over{20}}+0.1\right)\cr \left({{\sqrt
    {129}-9}\over{20}}+0.8\right)\,{\it x_2}+0.1\cr }= \
    pmatrix{0\cr 0\cr }\end{equation}
As our matrix has two rows, there are two equations that
    can be solved:
Solving the upper, results in $x2=-(sqrt(129)-7)/40$.
This results in an $x$ of:
\begin{equation}
x = \pmatrix{1.0\cr -{{\sqrt{129}-7}\over{40}}\cr }\end{
    equation}
$x$ must be rescaled so that its sum equals $1.0$.
$x$ its current sum is $1.0-(sqrt(129)-7)/40$, so
    dividing all elements by it, results in an $x$ of:
\begin{equation}
x = \pmatrix{{{1.0}\over{1.0-{{\sqrt{129}-7}\over{40}}}}\
    cr -{{\sqrt{129}-7}\over{40\,\left(1.0-{{\sqrt
    {129}-7}\over{40}}\right)}}\cr }\end{equation}
\section{Conclusion}

For this Leslie matrix:
\begin{equation}
\pmatrix{0.1&2.0\cr 0.1&0.8\cr }\end{equation}

The dominant eigenvalue, $\lambda$, is:
\\\\
\begin{equation}
\lambda = -(sqrt(129)-9)/20\end{equation}
\\

The stable population size distribution is:

\begin{equation}
x = \pmatrix{{{1.0}\over{1.0-{{\sqrt{129}-7}\over{40}}}}\
    cr -{{\sqrt{129}-7}\over{40\,\left(1.0-{{\sqrt
    {129}-7}\over{40}}\right)}}\cr }\end{equation}

\section{Discussion}

Writing \LaTeX~within Maxima can be done, but it is a bit
    cumbersome:
Maxima does not know \LaTeX~syntax and just creates
    contextless strings,
which might not be compilable by \LaTeX.
However, because the script does create a .tex file,
```

```
this file can be inspected easily with a \LaTeX~tool like
    texmaker.

\begin{thebibliography}{9}

\bibitem{case2000}
  Case, Ted J.
  2000
  An illustrated guide to theoretical ecology.

\bibitem{gaudeul2006}
  Gaudeul, A.
  2006
  Do Open Source Developers Respond to Competition?: The
     (La)TeX Case Study.
   Available at SSRN: http://ssrn.com/abstract=908946 or
     http://dx.doi.org/10.2139/ssrn.908946

\end{thebibliography}

\appendix

\section{Script file}

\lstinputlisting[language=C++,showstringspaces=false,
    breaklines=true,frame=single]{case_2000_69.sh}

\section{Maxima file}

\lstinputlisting[language=C++,showstringspaces=false,
    breaklines=true,frame=single]{case_2000_69.txt}

\section{\LaTeX~file}

\lstinputlisting[language=tex,showstringspaces=false,
    breaklines=true,frame=single]{case_2000_69_output.tex}

\end{document}
```