

Scipy library

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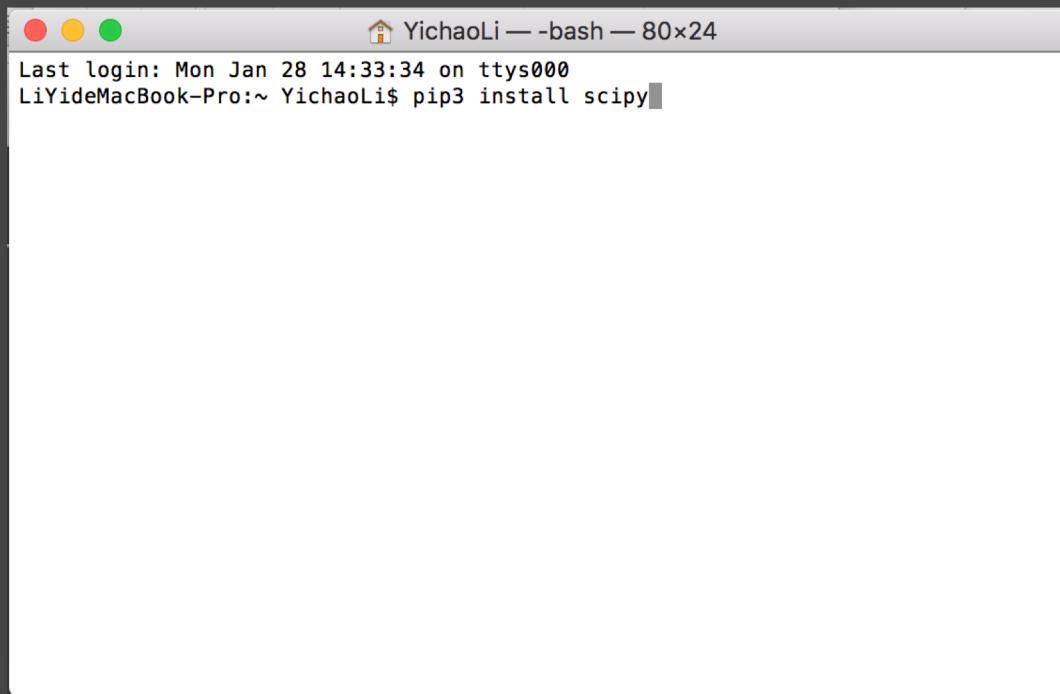
- Scipy has multiple definitions. As a programming ecosystem, Scipy includes libraries like Numpy, Sympy, Matplotlib, etc. As a library, Scipy provides a range of useful advanced scientific and mathematics algorithms Its primary functions include:
- Special functions
- Intergration
- Optimization
- Interpolation
- Fourier transforms
- Signal Processing
- Linear Algebra
- ...

In this book I will not introduce all the topics, partly due to the limited length of the book, but also partly due to my incapability to understand some of the algorithms

Introduction

Installation

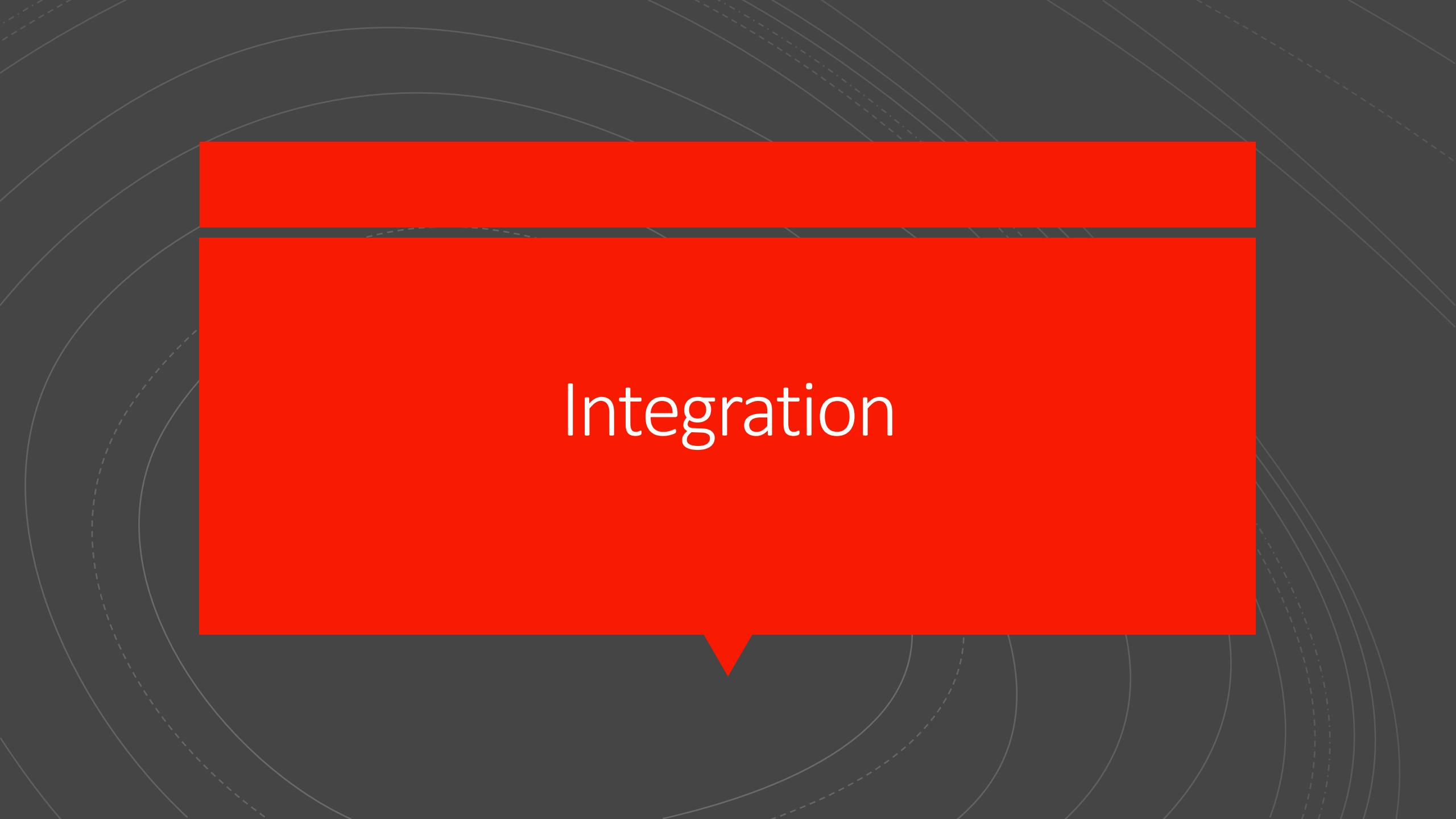
- The installation of the library is rather easy. Just like most other libraries, the `scipy` library can also be installed via the `pip` or `pip3` install command in the terminal.



A screenshot of a Mac OS X terminal window titled "YichaoLi — bash — 80x24". The window shows the command "pip3 install scipy" being typed at the prompt. The terminal interface includes standard Mac OS X window controls (red, yellow, green) and a title bar with the user name and session details.

```
Last login: Mon Jan 28 14:33:34 on ttys000
LiYideMacBook-Pro:~ YichaoLi$ pip3 install scipy
```

Like that easy!



Integration

General integration

- General integration works as the example shows:

```
1 import scipy.integrate as integrate
2 from scipy import linalg
3 import numpy as np
4
5
6 #Integration
7 result = integrate.quad(lambda x:x**2,0,1)#definite integral
8 print(result)
```

For integration, the `quad()` command is used. In the parenthesis, “lambda x” specifies what the function is integrating with respect to; the argument after the colon is the function to be integrated, and the final two arguments corresponds to the lower and upper limit of integration. In this example, “result” is the same as

$$\int_0^1 x^2 dx$$

Integrating a function with parameters

The quad() function can also integrate function with parameters in it. For example, for this integral

$$\int_0^1 ax^2 + bdx$$

the corresponding code in python would be

```
11 from scipy.integrate import quad
12 def integrand(x, a, b):
13     return a*x**2 + b
14
15 a = 2
16 b = 1
17 I = quad(integrand, 0, 1, args=(a,b))
18 print(I)
```

Where after the upper and lower limits, another argument, args = (a, b) is added to claim that a and b are parameters in this function

Double integration

Double integration can be achieved by using the `dblquad()` function. For example, if we were to integrate this function:

$$\int_{y=0}^{1/2} \int_{x=0}^1 xy dxdy$$

Then the code would be

```
27 #multiple integration
28 area = integrate.dblquad(lambda x, y: x*y, 0, 0.5, lambda x: 0, lambda x: 1-2*x)
29 print(area)
```

Similarly, first the variables in the function are claimed, then the actual function, upper and lower limits.

Matrix operations

Finding inverse matrix

Vectors and matrices are powerful math tools. Finding inverse of a matrix can also be useful, since it can give one the solution vector of a matrix rather easily. To find a inverse of a matrix, the scipy would use the linalg.inv() function:

```
31 #inverse matrix
32 from scipy import linalg
33 A = np.array([[1,3,5],[2,5,1],[2,3,8]])
34 linalg.inv(A)
35 print(A)
```

This corresponds to calculating the inverse of the matrix

$$\begin{matrix} 1 & 3 & 5 \\ 2 & 5 & 1 \\ 2 & 3 & 8 \end{matrix}$$

Why not Numpy???

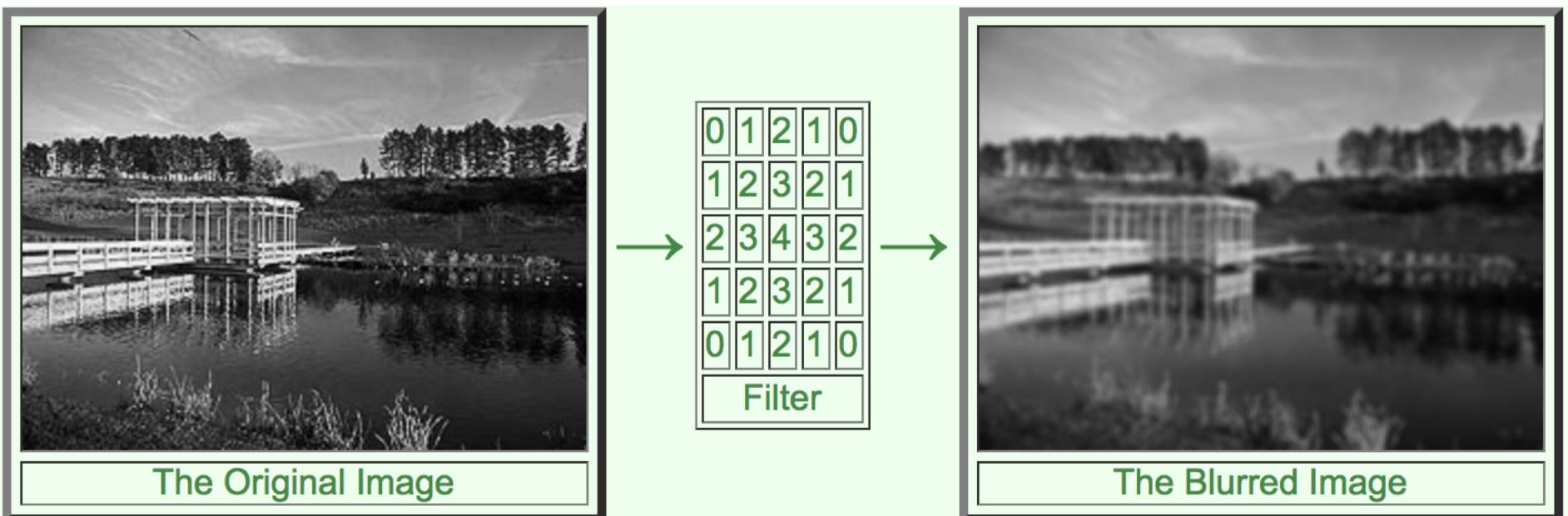
Notice that Numpy seems like a more related library to linear algebra. However, in fact, the scipy library is built on Numpy. In Numpy, if one wants to find a inverse matrix, he would do something like this:

```
>>> import numpy as np
>>> A = np.mat('1 2;3 4')
>>> A
matrix([[1, 2],
       [3, 4]])
>>> A.I
matrix([[-2.,  1.],
       [ 1.5, -0.5]])
```

So here the mat() function allows the user to enter a matrix that is stored as data in “matrix” format. This seems convenient and extremely easy to use, but the matrix type data is not as useful as numpy arrays. Arrays are more widely used in all kinds of data processing, while the matrix function serves solely as a matrix.

Applications

Matrices can often be related to image processing. An image can be transformed into a matrix, and the image matrix can be operated to manipulate the image. Filter is one of the tools that are used to manipulate images. For example, if we have this blurring filter here:



Application

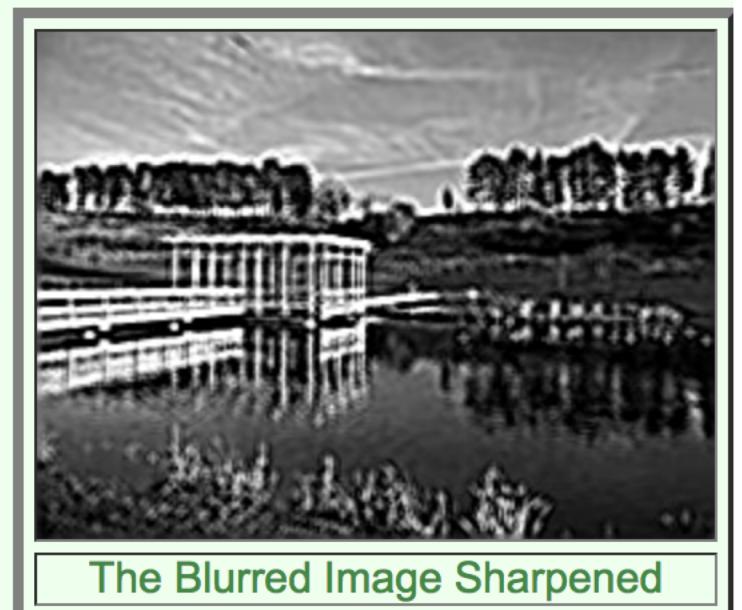
If the user finds the inverse of the blurring filter, and apply it to the blurred image, the user would be able to get a clearer image



→

0	-1	-2	-1	0
-1	-2	-3	-2	-1
-2	-3	40	-3	-2
-1	-2	-3	-2	-1
0	-1	-2	-1	0

"Inverse" Filter



Solving linear system

Solving linear system is the most basic part of linear algebra,
the code is rather easy.

```
38  
39 #solving linear system  
40  
41 A = np.array([[1,3,5],[2,5,1],[2,3,8]])  
42 b = np.array([[10],[8],[3]])  
43 x = np.linalg.solve(A, b)  
44 print(x)
```

For a general linear system, we have $Ax=b$. In this case, we have A and b as numpy arrays, and use the `np.linalg.solve()` function to solve the linear system.

Other useful functions

Some other useful functions in the Scipy library are the special functions(Bessel function, Cython bindings for special functions, etc.) and interpolation. The special function part provides a convenient way for mathematicians, scientists, and programmers to access these complicated algorithms.

Interpolation can also be very useful. A 2d image can also be seen as a contour map where colors represents the z value at a certain point. By using interpolation, filters can be applied to the image, and a blurred image can be smoothened.

Conclusion

In this book I have only mentioned functions that are the easiest to understand. As I mentioned in the beginning, the Scipy library has a lot of other advanced algorithms that are hard to understand as a high school student. This might not be useful for us now, but maybe it will one day in the future.

Sources

- <https://docs.scipy.org/doc/scipy/reference/>
- <https://www.cs.cornell.edu/boom/2003sp/ProjectArch/ConjugateGrad/index.htm>