Diese Aufgabe befaßt sich mit der Bildverarbeitung in *Mathematica*. Zu diesem Zweck müssen wir ein Bild in *Mathematica* einladen.

Aufgabe zu Graustufen-Bilder des Knochen etc.

■ Einlesen des .tiff Bildes

```
$Path = Join[$Path, {"/Users/wallrapp/Documents/Bone-Gray-Density"}]
```

```
{/Applications/Mathematica 5.2.app/AddOns/JLink,
 /Applications/Mathematica 5.2.app/AddOns/NETLink,
 /Users/wallrapp/Library/Mathematica/Kernel,
 /Users/wallrapp/Library/Mathematica/Autoload,
 /Users/wallrapp/Library/Mathematica/Applications, /Library/Mathematica/Kernel,
 /Library/Mathematica/Autoload, /Library/Mathematica/Applications, .,
 /Users/wallrapp, /Applications/Mathematica 5.2.app/AddOns/StandardPackages,
 /Applications/Mathematica 5.2.app/AddOns/StandardPackages/StartUp,
 /Applications/Mathematica 5.2.app/AddOns/Autoload,
 /Applications/Mathematica 5.2.app/AddOns/Applications,
 /Applications/Mathematica 5.2.app/AddOns/ExtraPackages,
 /Applications/Mathematica 5.2.app/SystemFiles/Graphics/Packages,
 /Applications/Mathematica 5.2.app/Configuration/Kernel,
 /Users/wallrapp/Documents/FH-Vorles/FH-Manuskript/Bone-Gray-Density,
 /Users/wallrapp/Documents/FH-Vorles/FH-Manuskript/Bone-Gray-Density,
 /Users/wallrapp/Documents/Bone-Gray-Density,
 /Users/wallrapp/Documents/Bone-Gray-Density}
```

```
data = Import["Bild-Bone.tiff", "TIFF"][[1, 1]];
```

Im Listenstrukturteil {1,1} befindet sich das Bild in Form einer 256*256 Matrix mit Grauwerten von 0 bis 255. Diese Matrix ist nun der Variable **data** zugeordnet und kann beispielsweise mit **ListDensityPlot** dargestellt werden.
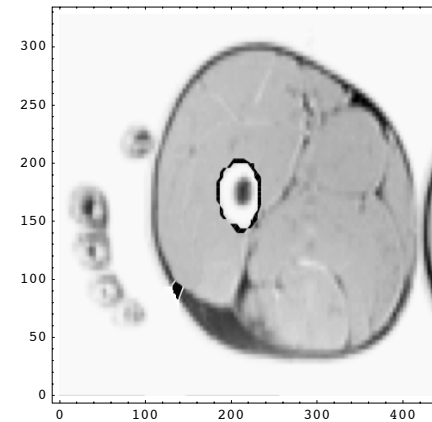
```
n = Dimensions[data]
```

```
{328, 444}
```

Weiss = 255, schwrz = 0!

```
data[[170]]
```

```
{247, 247, 247, 247, 247, 247, 247, 244, 244, 242, 238, 228, 224, 221, 216, 204, 199, 198,
 199, 201, 202, 201, 198, 190, 187, 183, 175, 153, 145, 140, 134, 116, 110, 107,
 103, 94, 90, 93, 104, 134, 145, 151, 158, 175, 182, 181, 172, 149, 140, 138, 142,
 151, 155, 161, 174, 213, 226, 232, 235, 243, 246, 247, 247, 247, 247, 247, 247,
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 237, 235, 234, 233, 231, 230, 223, 203, 149, 135, 122, 120, 114, 108, 106, 115,
 143, 171, 180, 180, 179, 177, 177, 177, 177, 177, 177, 176, 174, 172, 171, 172,
 174, 176, 177, 177, 178, 179, 179, 179, 178, 177, 177, 178, 180, 183, 184, 184,
 184, 184, 184, 183, 182, 180, 179, 178, 177, 176, 175, 175, 175, 175, 175, 175,
 175, 175, 175, 175, 175, 175, 175, 176, 176, 176, 177, 177, 177, 177, 177, 177,
 176, 176, 176, 165, 0, 0, 0, 14, 212, 233, 239, 240, 243, 246, 247, 247, 246, 245,
 245, 242, 234, 226, 223, 215, 188, 161, 153, 142, 112, 81, 70, 69, 63, 57, 56, 58,
 65, 72, 74, 81, 101, 122, 129, 140, 174, 208, 219, 222, 231, 240, 243, 223, 0, 0,
 0, 16, 195, 177, 171, 171, 171, 171, 171, 171, 173, 174, 174, 176, 180, 185, 187,
 186, 183, 179, 178, 173, 158, 143, 138, 133, 120, 108, 103, 108, 121, 133, 138,
 141, 150, 160, 163, 163, 162, 161, 161, 162, 165, 167, 168, 168, 168, 169, 169,
 169, 169, 168, 168, 166, 161, 157, 155, 154, 153, 151, 150, 150, 152, 154, 156,
 157, 158, 162, 163, 164, 164, 167, 167, 167, 167, 167, 167, 167, 167, 166, 166,
 166, 166, 166, 166, 166, 166, 165, 165, 165, 164, 162, 161, 161, 161, 162, 162,
 161, 161, 159, 159, 158, 156, 153, 151, 151, 151, 150, 150, 150, 152, 156, 158,
 157, 154, 147, 144, 141, 134, 116, 109, 110, 119, 143, 152, 156, 158, 163, 165,
 166, 168, 172, 174, 171, 162, 139, 130, 125, 117, 97, 89, 89, 97, 115, 123, 127,
 133, 148, 154, 157, 159, 165, 167, 168, 168, 168, 168, 168, 167, 165, 164, 164,
 163, 163, 162, 162, 162, 160, 160, 159, 157, 153, 151, 151, 153, 158, 160, 163,
 169, 186, 192, 196, 203, 219, 226, 227, 225, 219, 217, 210, 193, 148, 131, 119,
 101, 52, 34, 35, 55, 110, 130, 139, 146, 166, 173, 175, 175, 173, 173, 173, 173}
```

```
ListDensityPlot[data, Mesh -> False];
```


■ Lösung

```
<< Statistics`DataManipulation`
```

```
Spektrum = CategoryCounts[Flatten[data], Range[0, 255]];
```

```
Length[Spektrum]
```

256

```
ListPlot[Spektrum, PlotRange → {Automatic, {0, 3000}}];
```


Wahrscheinlichkeiten der Grauwerte:

```
P = Spektrum / Apply[Plus, Spektrum];
```

Anwendung der Formel $I = -\sum_i p_i \log_2 p_i$. (Der Fall $p_i = 0$ erfordert eine Fallunterscheidung)

```
Apply[Plus, Map[If[# > 0, -# Log[2, #], 0] &, N[P]]]
```

5.0486

Die Grauwerte benötigen im Durchschnitt 5.05 Bits pro Pixel. Würde man diese Tatsache ausnutzen, würde die Bilddatei nicht 65536 Bytes sondern nur 55152 Bytes benötigen.

■ Auswahl von Grauwerten (suche dunkle Stellen. < 70, bzw. setze hellere Stellen auf weiss = 255

```
Do[Do[
    If[data[[i, j]] > 70, data[[i, j]] = 255;];
    , {i, 1, n[[1]]}];, {j, 1, n[[2]]}];
```

```
data[[170]]
```

{255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255,
 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255,
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 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255,
 255, 255, 0, 0, 0, 14, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255,
 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 70, 69, 63, 57, 56, 58, 65, 255,
 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 0, 0, 0, 16,
 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255,
 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255,
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 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255,
 255, 52, 34, 35, 55, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255}

```
ListDensityPlot[data, Mesh -> False];
```

Aufgabe zur Bewegungsanalyse

wir lesen das Bild RuderErgometer2003-fig1.tiff ein und suche die Markerpunkte

```
data = Import["RuderErgometer2003-fig1.tiff", "TIFF"][[1, 1]];
```

Im Listenstrukturteil {1,1} befindet sich das Bild in Form einer 256*256 Matrix mit Grauwerten von 0 bis 255.
Diese Matrix ist nun der Variable **data** zugeordnet und kann beispielsweise mit **ListDensityPlot** dargestellt
werden.

```
n = Dimensions[data]
```

{199, 332}

Weiss = 255, schwrz = 0!

```
data[[100]]
```

{13, 14, 14, 13, 11, 17, 16, 15, 14, 14, 14, 15, 16, 12, 13, 14, 15, 16, 15, 15, 14,
130, 17, 2, 15, 10, 15, 7, 19, 8, 11, 13, 17, 27, 36, 36, 30, 27, 22, 26, 29, 22,
20, 26, 27, 24, 25, 26, 28, 30, 32, 34, 35, 22, 25, 26, 22, 17, 15, 15, 15, 16,
15, 14, 16, 19, 22, 23, 23, 24, 23, 23, 23, 19, 14, 15, 19, 17, 20, 17, 17, 18,
12, 16, 32, 38, 20, 15, 20, 19, 18, 19, 14, 12, 15, 22, 38, 57, 73, 83, 86, 57,
48, 37, 30, 23, 17, 15, 16, 16, 14, 15, 19, 24, 25, 21, 17, 13, 15, 23, 34, 42,
45, 47, 51, 47, 53, 57, 55, 49, 46, 49, 54, 51, 55, 61, 65, 66, 67, 69, 71, 74,
74, 74, 73, 70, 67, 64, 63, 73, 70, 68, 71, 77, 80, 80, 78, 92, 94, 96, 99, 105,
115, 126, 134, 138, 136, 143, 167, 183, 169, 149, 147, 135, 133, 117, 102, 96,
87, 80, 83, 71, 76, 71, 70, 74, 60, 56, 77, 52, 21, 18, 19, 19, 1, 11, 18, 9, 9,
10, 11, 11, 10, 8, 7, 3, 0, 0, 15, 2, 5, 9, 5, 11, 0, 13, 4, 17, 12, 16, 8, 10, 0,
8, 4, 14, 8, 11, 8, 0, 0, 4, 3, 7, 9, 4, 7, 3, 15, 11, 2, 11, 3, 16, 0, 14, 0, 22,
6, 3, 9, 10, 19, 13, 0, 16, 1, 11, 14, 8, 4, 12, 0, 12, 5, 7, 8, 4, 9, 16, 2, 6, 9,
11, 6, 12, 1, 150, 8, 12, 6, 9, 6, 13, 3, 13, 2, 6, 11, 27, 44, 47, 59, 86, 94, 96,
99, 110, 114, 116, 125, 144, 136, 136, 147, 151, 144, 135, 131, 131, 134, 131,
125, 127, 130, 119, 101, 52, 32, 36, 35, 13, 12, 25, 17, 3, 9, 12, 9, 7, 9, 10}
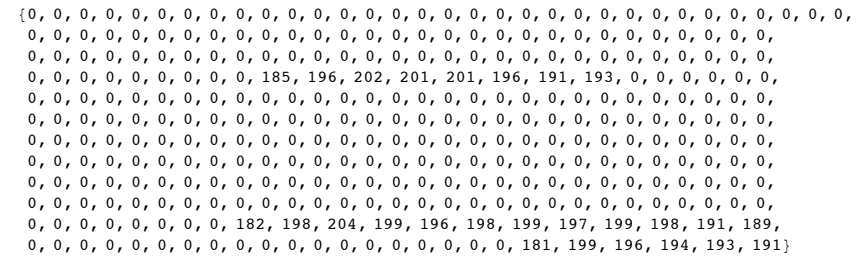
```
ListDensityPlot[data, Mesh -> False, AspectRatio → Automatic];
```
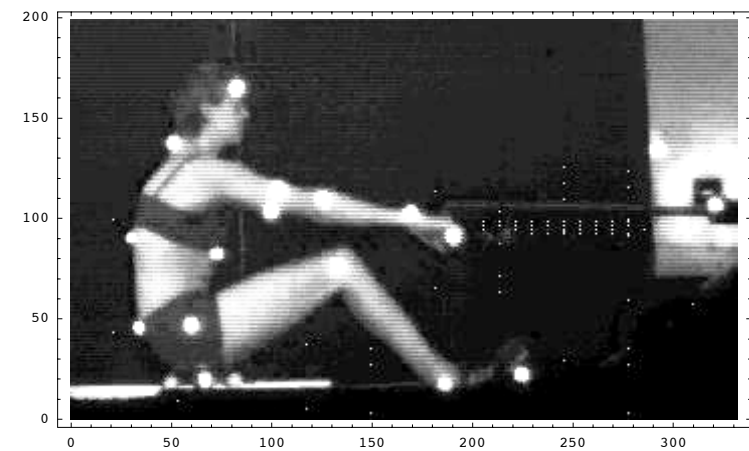


```
data[[115]]
```

{16, 16, 16, 16, 16, 16, 16, 16, 16, 16, 16, 16, 16, 16, 16, 16, 16, 16, 16, 16, 16,
16, 16, 16, 16, 16, 16, 16, 16, 15, 20, 17, 17, 15, 5, 21, 62, 126, 136, 132, 148,
146, 137, 98, 84, 109, 121, 135, 133, 155, 153, 157, 155, 165, 167, 168, 166, 163,
160, 160, 161, 151, 152, 153, 151, 148, 145, 144, 144, 121, 121, 118, 117, 119,
121, 123, 126, 123, 126, 131, 134, 136, 138, 139, 141, 146, 152, 154, 150, 148,
149, 150, 147, 149, 144, 147, 162, 146, 167, 185, 196, 202, 201, 201, 196, 191,
193, 177, 147, 148, 118, 114, 106, 100, 89, 68, 56, 63, 58, 54, 59, 72, 82, 80,
73, 66, 76, 80, 74, 62, 51, 37, 27, 8, 22, 15, 9, 20, 15, 9, 24, 18, 13, 15, 16, 10,
11, 15, 11, 14, 15, 16, 16, 15, 15, 15, 15, 16, 18, 19, 18, 16, 15, 17, 18, 17, 16,
15, 14, 15, 15, 15, 14, 18, 17, 17, 16, 16, 16, 16, 16, 5, 3, 10, 16, 12, 13, 17,
13, 15, 14, 14, 14, 14, 14, 14, 15, 15, 14, 13, 12, 11, 11, 11, 11, 17, 14, 13, 9,
11, 10, 14, 14, 12, 12, 12, 13, 13, 13, 13, 13, 13, 11, 12, 15, 15, 12, 10, 12, 15,
11, 10, 13, 14, 12, 11, 12, 10, 10, 11, 11, 11, 10, 9, 8, 21, 7, 0, 1, 12, 11, 11,
20, 11, 11, 10, 10, 10, 10, 11, 11, 8, 9, 9, 8, 6, 6, 7, 10, 10, 10, 10, 11, 10, 8, 7,
7, 8, 19, 0, 2, 12, 11, 10, 10, 23, 13, 8, 16, 35, 60, 93, 119, 125, 170, 171, 182,
198, 204, 199, 196, 198, 199, 197, 199, 198, 191, 189, 176, 153, 111, 51, 37, 29,
9, 18, 33, 37, 23, 44, 31, 4, 38, 23, 36, 99, 150, 181, 199, 196, 194, 193, 191}

◼ **Filter: alles was dunkler ist als 180 setzen wir schwarz = 0**

```
Do[Do[
    If[data[[i, j]] < 180, data[[i, j]] = 0;];
    , {i, 1, n[[1]]}];, {j, 1, n[[2]]}];
ListDensityPlot[data, Mesh -> False, AspectRatio → Automatic];
data[[115]]
```



```
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
 0, 0, 0, 0, 0, 0, 0, 0, 185, 196, 202, 201, 201, 196, 191, 193, 0, 0, 0, 0, 0, 0,
 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
 0, 0, 0, 0, 0, 0, 0, 0, 182, 198, 204, 199, 196, 198, 199, 197, 199, 198, 191, 189,
 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 181, 199, 196, 194, 193, 191}
```

Hier könnte man nun aus der Matrix die Zeilen / Spalen holen, die wir für die Koordinate, z.B. des Handgelnks benötigen.

usw.