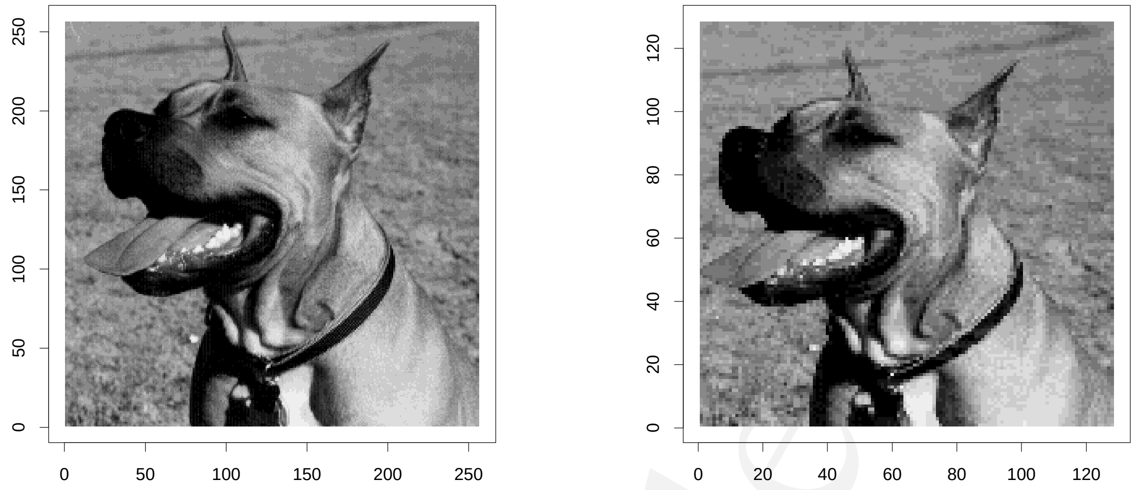

Figure 1: Buff at 256 x 256 and 128 x 128 resolutions

Getting Started with S+Wavelets (2-D)

Introduction

```
>  Buff.dwt_dwt.2d(Buff, n.levels=4, wavelet="d10")
>  postscript("/daub4/local/brani/sta293/Buffdwt.ps",  horizontal=F, width=6.5, height=7.1)
>  plot(Buff.dwt)
>  dev.off()
>  # Figure 2.


> crystal.names(Buff.dwt)
     L-H     H-L     H-H   LL-HL   HL-LL   HL-HL LLL-HLL HLL-LLL HLL-HLL
 "s1-d1" "d1-s1" "d1-d1" "s2-d2" "d2-s2" "d2-d2" "s3-d3" "d3-s3" "d3-d3"
 LLLL-HLLL HLLL-LLLL HLLL-HLLL LLLL-LLLL
 "s4-d4"   "d4-s4"   "d4-d4"   "s4-s4"
> crystal.s3d3_Buff.dwt[["s3-d3"]]
>  crystal.s3d3
2D Wavelet packet crystal: s3-d3
```

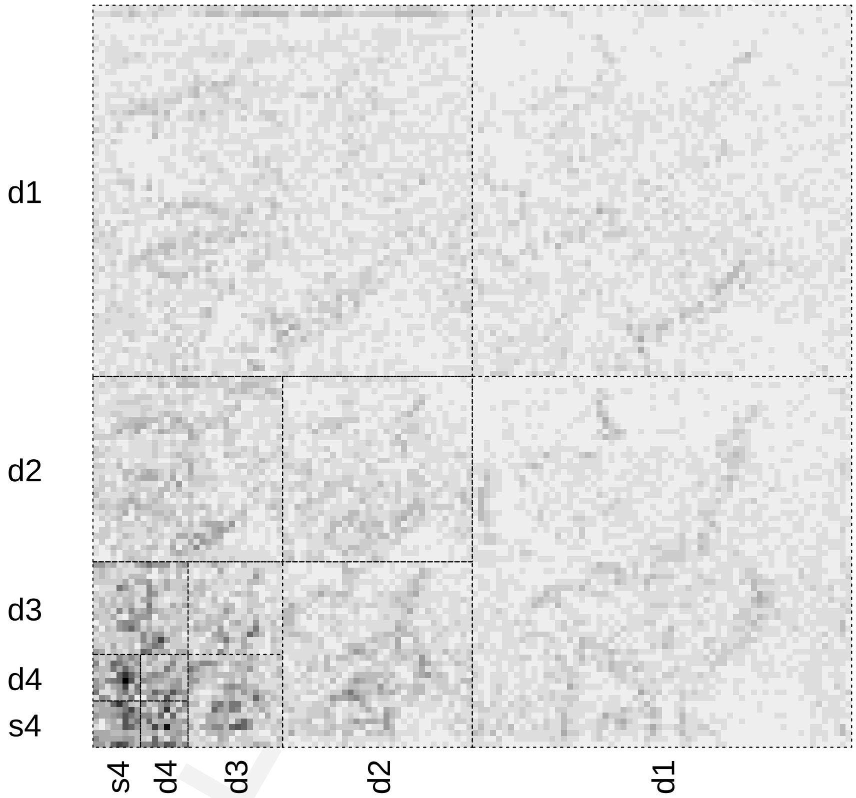

Figure 2: 2-D Discrete Wavelet Transformation of `Buff`

```
Image Dimensions:  128 by 128
Number of Levels:  4
Horizontal Wavelet:  d10
Vertical Wavelet:  d10
Horizontal Boundary Rule:  periodic
Vertical Boundary Rule:  periodic

             [,1]       [,2]       [,3]       [,4]       [,5]       [,6]
 [1,]  134.544705 -34.434176  28.260994 -19.005076 -76.781160  -4.306987
 [2,]   97.971851 -46.230585 -19.664520  31.002000   4.047312 -40.970732
 .
 .
 .
           [,13]       [,14]      [,15]      [,16]
 [1,]   34.15691 -35.9033808  23.467608 -190.43798
 [2,]   25.66980 -53.2240691 -53.732437 -163.60624
 .
 .
 .
[15,]  -43.81851 -48.2182138  53.029302 -130.97765
[16,]   27.41561   5.0501006  46.876119 -141.73603

> image(crystal.s3d3)
> # Figure 3.


> new.Buff_idwt.2d(Buff.dwt)
> max( abs( new.Buff - Buff))
[1] 1.250555e-12
```

Denoising

```
>  Buff.flee_Buff+rnorm(128*128, s=40)
>  image(Buff.flee)
>  Figure  4 (a)
>  Buff.flee.dwt_dwt.2d( Buff.flee, wavelet="d10", n.levels=4)
>  thresh_rep(0,13)
>  thresh[-13]_quantile(abs(as.vector(Buff.flee.dwt)), 0.8)
>  Clean.Buff_shrink( Buff.flee.dwt, threshold=thresh)
>  Clean.Buff_reconstruct(Clean.Buff)
>  image(Clean.Buff)
>  Figure  4 (b)


        V1 <- Buff.dwt[["d1-s1"]]
        D1 <- Buff.dwt[["d1-d1"]]
        H1 <- Buff.dwt[["s1-d1"]]  #------------level2-------------
        V2 <- Buff.dwt[["d2-s2"]]
```

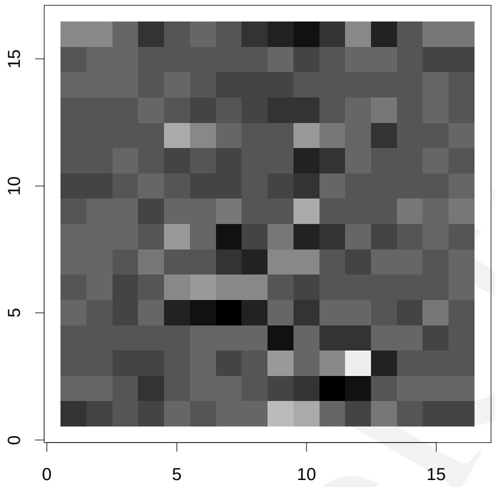

Figure 3: Crystal c3-d3: (H3 matrix)

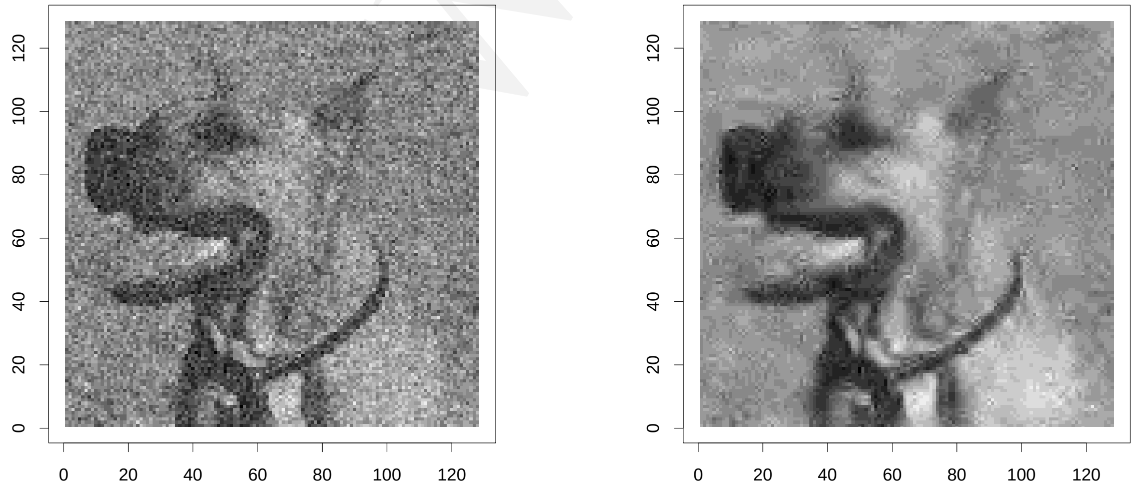

Figure 4: (a) Noised Buff. Normal $N(0, 40^2)$ noise. (b) Cleaned Buff, 20% of information.

```
D2 <- Buff.dwt[["d2-d2"]]
H2 <- Buff.dwt[["s2-d2"]]  #------------level3-------------
V3 <- Buff.dwt[["d3-s3"]]
D3 <- Buff.dwt[["d3-d3"]]
H3 <- Buff.dwt[["s3-d3"]]  #------------level4-------------
V4 <- Buff.dwt[["d4-s4"]]
D4 <- Buff.dwt[["d4-d4"]]
H4 <- Buff.dwt[["s4-d4"]]
S4 <- Buff.dwt[["s4-s4"]]  #-------------------------------

%do something with Vs, Ds, and Hs.

Buff.dwt[["d1-s1"]] <- V1T
Buff.dwt[["d1-d1"]] <- D1T
Buff.dwt[["s1-d1"]] <- H1T #-------
Buff.dwt[["d2-s2"]] <- V2T
Buff.dwt[["d2-d2"]] <- D2T
Buff.dwt[["s2-d2"]] <- H2T #-------
Buff.dwt[["d3-s3"]] <- V3T
Buff.dwt[["d3-d3"]] <- D3T
Buff.dwt[["s3-d3"]] <- H3T #--------
Buff.dwt[["d4-s4"]] <- V4
Buff.dwt[["d4-d4"]] <- D4
Buff.dwt[["s4-d4"]] <- H4  #--------
Buff.dwt[["s4-s4"]] <- S4
Brand.new.Buff <- reconstruct(Buff.dwt)
```

2-D Wavelet Packets

```
>  plot(wavelet.packet.2d(wavelet="d10", oscillation=c(5,2)), , eye=c(5,-5, 3))
> # Figure  5.
Horizontal Function: Wavelet Packet Function:
Wavelet name: d10
Oscillation: 5
Level: 0
Shift: 0

Vertical Function: Wavelet Packet Function:
Wavelet name: d10
Oscillation: 2
Level: 0
Shift: 0


> Buff.wpt_wpt.2d(Buff, n.level=4)
> plot( Buff.wpt)
> #Figure 6.
```

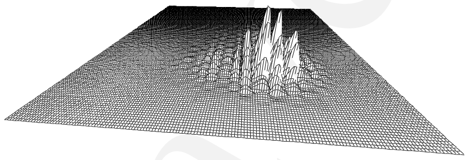

Figure 5: 2-d packet, Daub 10, oscillation (5,2)

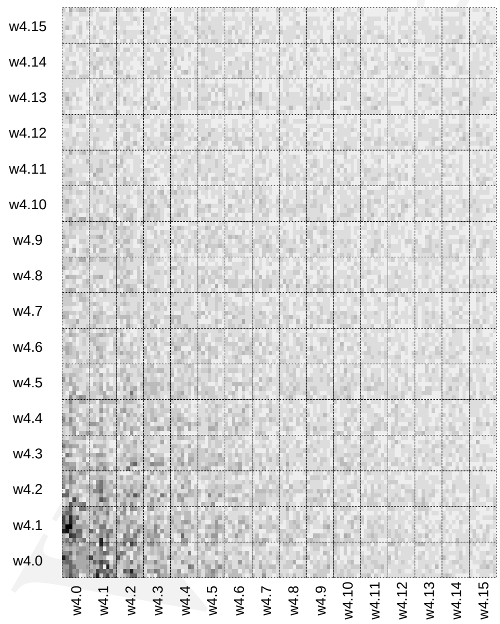

Figure 6: Wavelet Packet Decomposition

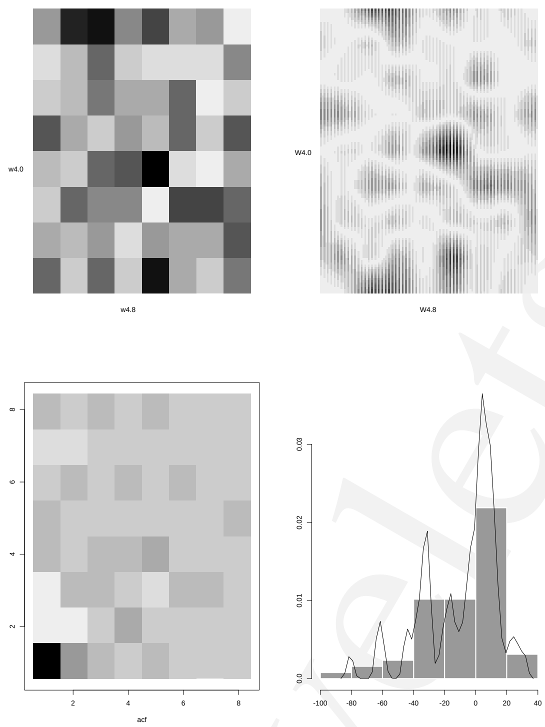

Figure 7: Wavelet Packet Decomposition

```
> crystal.names( Buff.wpt)
   LLLL-LLLL   HLLL-LLLL   HHLL-LLLL   LHLL-LLLL   LHHL-LLLL   HHHL-LLLL
 "w4.0-w4.0" "w4.1-w4.0" "w4.2-w4.0" "w4.3-w4.0" "w4.4-w4.0" "w4.5-w4.0"
   HLHL-LLLL   LLHL-LLLL   LLHH-LLLL   HLHH-LLLL    HHHH-LLLL    LHHH-LLLL
 "w4.6-w4.0" "w4.7-w4.0" "w4.8-w4.0" "w4.9-w4.0" "w4.10-w4.0" "w4.11-w4.0"
 .
 .
 .
     LLHH-LLLH    HLHH-LLLH     HHHH-LLLH     LHHH-LLLH     LHLH-LLLH
 "w4.8-w4.15" "w4.9-w4.15" "w4.10-w4.15" "w4.11-w4.15" "w4.12-w4.15"
     HHLH-LLLH     HLLH-LLLH     LLLH-LLLH
 "w4.13-w4.15" "w4.14-w4.15" "w4.15-w4.15"
> eda.plot( Buff.wpt[["w4.8-w4.0"]])
> # Figure 7 .
```