Comparison between Dr. Mitchell's pipeline and ours

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Pipeline differences 1 - Normalization difference

- Dr. Mitchell's pipeline:

```
def MitchelGrayScaleNormalization(imgArray,imgMax,imgMin):
    imgRange = imgMax - imgMin
    imgArray = (imgArray - imgMin) * 256.0 / imgRange)

    # transfer to closest int
    imgArray = numpy.rint(imgArray).astype numpy.uint8)

    return imgArray
```

- Ours:

```
def GrayScaleNormalization(imgArray, imgMax,imgMin):

    imgRange = imgMax - imgMin
    imgArray = (imgArray - imgMin) * (255.0 / imgRange)

    # transfer to closest int
    imgArray = numpy.rint(imgArray).astyp (numpy.int16)

    return imgArray
```

Difference 1:

Dr. Mitchell's pipeline increases normalization from [0, 255] to [0, 256].

Our pipeline still uses [0, 255] to normalize gray scale.

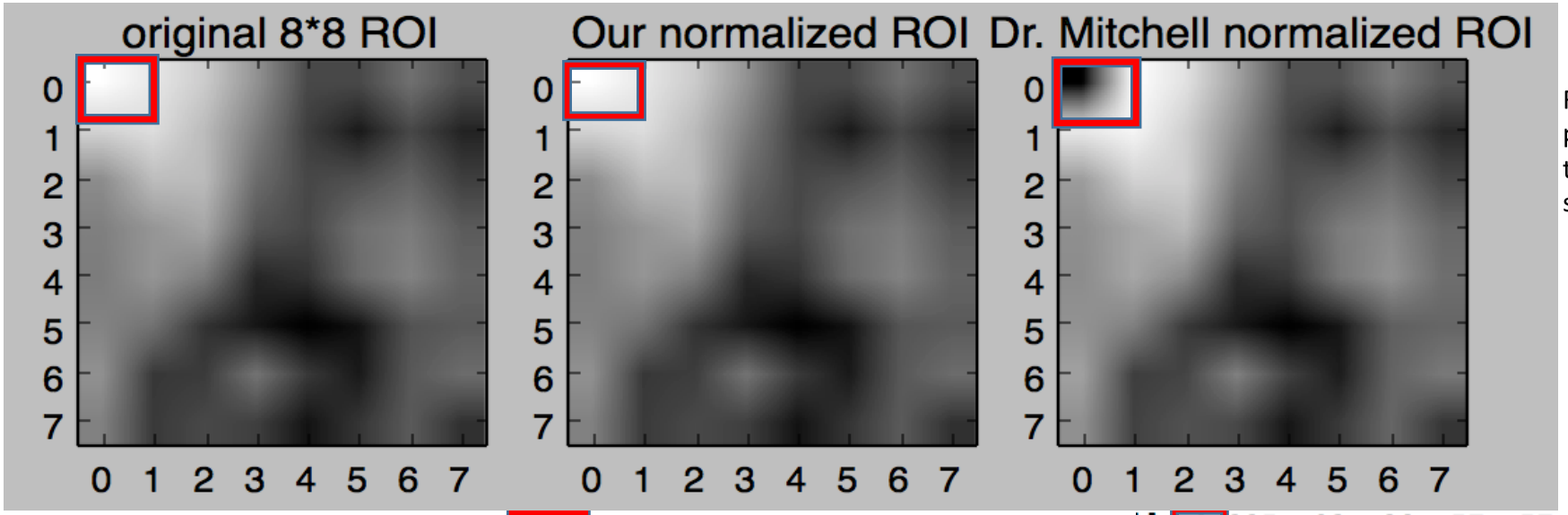
Difference 2:

After Dr. Mitchell's pipeline gets 256 gray scale, it uses 'uint8' transfer 256 to 0. Which means brightest pixel turns to darkest pixel.

Our pipeline keeps original number, which means 255 is still 255.

ROI comparison Example1

Rwh: slice 17, slice coordinate (x, y) = (161,126), dicom file: *Ax_T2_FSE_INTER_IM-0001-0017.dcm*



For some other points' gray scales, they increase 1 gray scale level

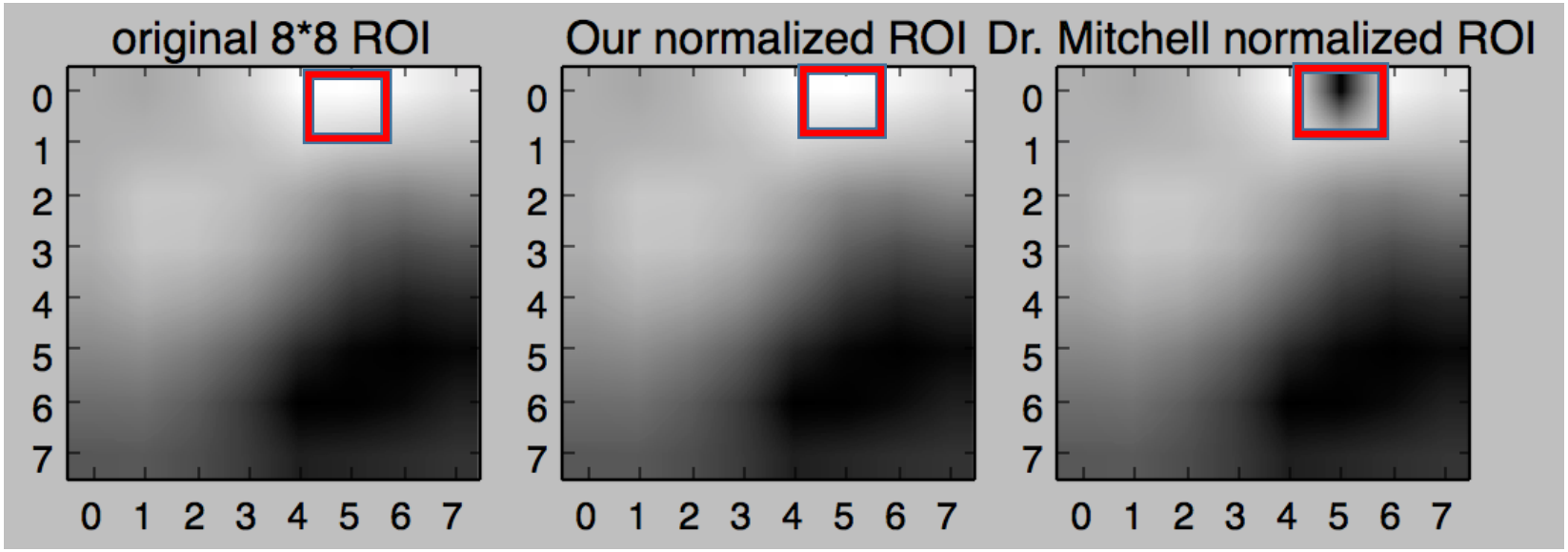
```
[[1268 1252 1235 1201 1164 1164 1183 1166]
 [1239 1246 1225 1191 1159 1144 1163 1148]
 [1198 1226 1225 1181 1163 1167 1177 1160]
 [1191 1203 1213 1170 1163 1183 1189 1173]
 [1190 1203 1189 1149 1154 1181 1193 1176]
 [1193 1184 1154 1143 1134 1142 1169 1172]
 [1200 1156 1158 1185 1157 1144 1171 1181]
 [1192 1157 1164 1160 1142 1155 1172 1153]]
```

```
[[255 225 192 128  57  57  93  61]
 [200 213 173 108  48  19  55  27]
 [122 175 173  89  55  63  82  49]
 [108 131 150  69  55  93 105  74]
 [107 131 105  29  38  89 112  80]
 [112  95  38  17   0  15  67  72]
 [126  42  46  97  44  19  70  89]
 [110  44  57  49  15  40  72  36]]
```

```
[[  0 225 193 128  57  57  94  61]
 [201 214 174 109  48  19  55  27]
 [122 176 174  90  55  63  82  50]
 [109 132 151  69  55  94 105  75]
 [107 132 105  29  38  90 113  80]
 [113  96  38  17   0  15  67  73]
 [126  42  46  97  44  19  71  90]
 [111  44  57  50  15  40  73  36]]
```

ROI comparison Example2

Rwh: slice 17, slice coordinate (x, y) = (161,126), dicom file: **EPI+C_IM-0003-0017.dcm**



For some other gray scales, they increase 1 gray scale level

```
[[4054 4033 4073 4163 4311 4317 4283 4210]
 [4055 4067 4076 4109 4173 4145 4120 4100]
 [4063 4133 4131 4097 4029 3939 3914 3952]
 [4054 4123 4115 4060 3954 3828 3778 3805]
 [4006 4053 4025 3952 3831 3724 3680 3700]
 [3934 3953 3902 3816 3695 3638 3621 3641]
 [3865 3870 3817 3734 3620 3623 3647 3684]
 [3810 3812 3786 3743 3683 3696 3712 3725]]
```

```
[[159 151 166 199 253 255 243 216]
 [159 164 167 179 202 192 183 176]
 [162 188 187 175 150 117 108 121]
 [159 184 181 161 122  76  58  68]
 [141 158 148 121  77  38  22  29]
 [115 122 103  72  27   7   0   8]
 [ 90  91  72  42   0   1  10  23]
 [ 70  70  61  45  23  28  34  38]]
```

```
[[159 152 166 199 254   0 244 217]
 [160 164 167 180 203 193 184 176]
 [163 188 188 175 150 117 108 122]
 [159 185 182 162 123  76  58  68]
 [142 159 149 122  77  38  22  29]
 [115 122 104  72  28   7   0   8]
 [ 90  92  72  42   0   1  10  24]
 [ 70  71  61  45  23  28  34  39]]
```

Pipeline differences 2 – LBP Border effect

LBP radius = 3

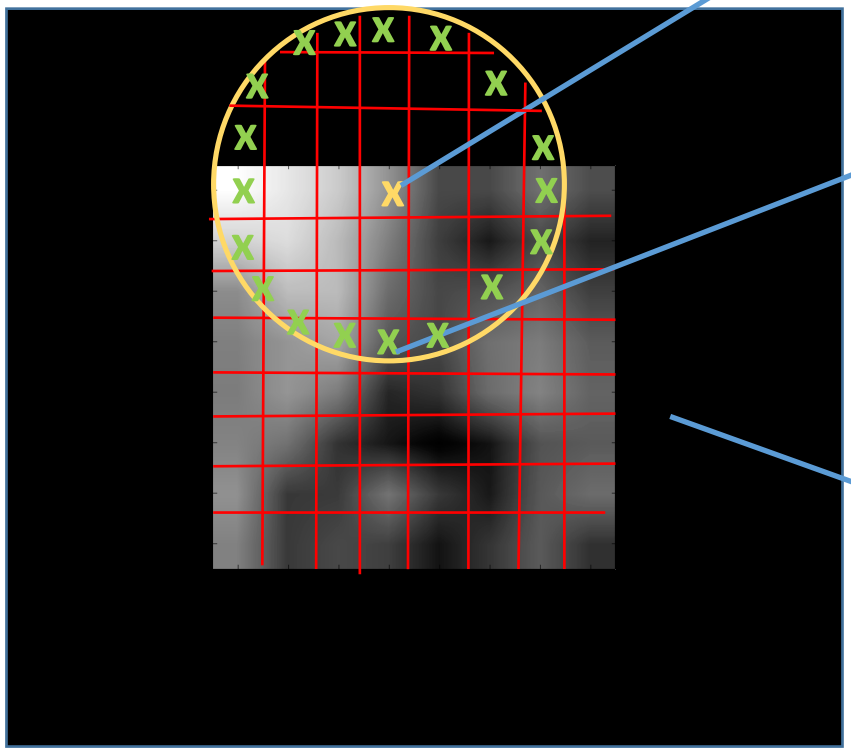
- Why LBP Border effect matters?

```
[[0    0    0    0    0    0    0    0 ]
[0    0    0    0    0    0    0    0 ]
[0    0    0    0    0    0    0    0 ]
[0    0    0    0    0    0    0    0 ]
[1268 1252 1235 1201 1164 1164 1183 1166]
[1239 1246 1225 1191 1159 1144 1163 1148]
[1198 1226 1225 1181 1163 1167 1177 1160]
[1191 1203 1213 1170 1163 1183 1189 1173]
[1190 1203 1189 1149 1154 1181 1193 1176]
[1193 1184 1154 1143 1134 1142 1169 1172]
[1200 1156 1158 1185 1157 1144 1171 1181]
[1192 1157 1164 1160 1142 1155 1172 1153]]
```

Compare each LBP border point gray scale with center gray scale to get binary number:

if gray scale of border < center gray scale: 0
Otherwises, 1

For this point, LBP: 000000000 000001111
First 9 numbers 0 are all in 0 padding area, 0 padding results in an artifact in LBP calculation



Box border points

Box border points,
LBP radius = 3, means with center of point, get points' grayscale of circle with radius = 3.

All black outside 8x8 ROI box, which means grayscale outside are all 0. Dr. Mitchell's pipeline includes some 0 gray scale into LBP when calculating LBP for some points especially border points

Dr. Mitchell's pipeline: 8*8 box with 0 padding outside

Pipeline differences 2 – LBP Border Handling difference

LBP radius = 1/3

- Dr. Mitchell's LBP calculation:

```
subImage = dicomImage[ycoord-4:ycoord+4,xcoord-4:xcoord+4]
subImageMitchel = MitchelGrayScaleNormalization(subImage, subImage.max(),subImage.min())
LBPRoss = LBPFeatures.calcFeatures(subImageMitchel,LBPnPoints, LBPRadius, LBPMethod)
```

- Ours:

```
subImageLBP = dicomImage[ycoord - 4 - LBPRadius:ycoord + 4 + LBPRadius, xcoord - 4 - LBPRadius: xcoord + 4 + LBPRadius]
extendsubImageLBP = GrayScaleNormalization(subImageLBP, subImage.max(),subImage.min())
LBPs = ExtendLBPFeatures.calcFeatures(extendsubImageLBP, LBPnPoints, LBPRadius, LBPMethod)
```

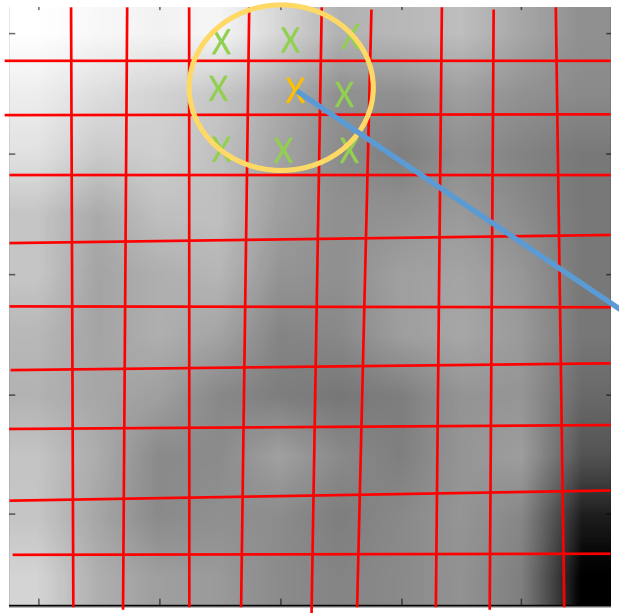
Difference:

Dr. Mitchell's pipeline uses original 8*8 box to process LBP features, but it cannot solve LBP border effect. We use extended box to process LBP features, which solve LBP border effect

LBP border handling Example

Rwh: slice 17, slice coordinate (x, y) = (161,126), dicom file: *Ax_T2_FSE_INTER_IM-0001-0017.dcm*

LBP radius = 1



Our LBP: extended 10*10 box

[[1316 1305 1297 1302 1256 1208 1215 1223 1193 1163]
[1290 1268 1252 1235 1201 1164 1164 1183 1166 1157]
[1272 1239 1246 1225 1191 1159 1144 1163 1148 1136]
[1232 1198 1226 1225 1181 1163 1167 1177 1160 1136]
[1234 1191 1203 1213 1170 1163 1183 1189 1173 1136]
[1215 1190 1203 1189 1149 1154 1181 1193 1176 1134]
[1208 1193 1184 1154 1143 1134 1142 1169 1172 1118]
[1231 1200 1156 1158 1185 1157 1144 1171 1181 1093]
[1232 1192 1157 1164 1160 1142 1155 1172 1153 1043]
[1253 1203 1182 1176 1158 1150 1157 1167 1144 1017]]

For this point in Our LBP:
11100011
This is real LBP for this border point, because it solved 0 padding effect

After we get real LBP of extended 10*10 box points , we will zoom back to 8*8 box to only get LBP of 8*8 box points

Summary

- 1. Dr. Mitchell's pipeline normalizes gray scale to [0, 256] then made brightest points to darkest points.
- Our pipeline normalizes gray scale of ROI box to [0, 255].

- 2. Dr. Mitchell's pipeline uses 0 padding to calculate LBP for some points especially border points of ROI box.
- Our pipeline does not use 0 padding. We use extended box for eliminating LBP border effects and guarantees each point of ROI box has real LBP.