Extracting Structural Information from Images of Spiral Galaxies

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Computer vision is hard. Find the tiger!
(courtesy of Kobus Barnard, U. Arizona)
This looks trivial! Why is it so hard?

- you have an unfair advantage over the computer
- if you can’t find the tiger, the tiger will find you

⇒ strong evolutionary pressure to recognize stuff

- 25-50% of your brain is devoted to vision
- that’s a lot of compute power

The reason I’m showing you all this is simply to demonstrate that although the stuff I’m about to show you looks trivial to the untrained eye, it’s really not. I want to impress upon you the mind-boggling amount of pain and suffering that computer vision people are going through in order to create algorithms to do what you can do with a casual glance.
Vision is easy for humans

On the next slide, two images.

Question: which galaxy has more arms, the left one or the right one?

You have 1 second.

Are you ready?
Vision is easy for humans

(Gosh, I hope this works...)

How did we do?
Vision is easy for humans

(Gosh, I hope this works...)

How did we do?

Great! Let’s give up on computers, and use humans!

You’re all hired.
You thought I was kidding... The Galaxy Zoo Project has 250,000 human volunteers who classify images over the web.

Problem: 250,000 humans isn’t enough for $10^{11}$ galaxies, and humans are not good at objective quantitative measurement.
Our method

- input: PNG, JPG or FITS
- find, size + centre using 2D gaussian fit
- de-project to “circularize”
- cluster pixels to find blobs
- fit log-spiral arcs to blobs
- output: list of arm segments + their parameters
30,000 galaxy comparison with 250,000 Humans (Galaxy Zoo 2)

1. Winding Direction

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>60</th>
<th>80</th>
<th>90</th>
<th>95</th>
<th>100</th>
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</thead>
<tbody>
<tr>
<td>Min Discernibility Rate</td>
<td></td>
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<tr>
<td>Inclusion Rate</td>
<td>67.0</td>
<td>64.7</td>
<td>55.7</td>
<td>39.0</td>
<td>25.1</td>
<td>10.0</td>
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<tr>
<td>Majority Vote</td>
<td>79.5</td>
<td>79.8</td>
<td>81.0</td>
<td>83.1</td>
<td>84.6</td>
<td>84.8</td>
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<tr>
<td>Longest Arc alone</td>
<td>95.3</td>
<td>95.7</td>
<td>96.5</td>
<td>97.8</td>
<td>98.3</td>
<td>98.4</td>
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<tr>
<td>Length-weighted Vote</td>
<td>94.9</td>
<td>95.3</td>
<td>96.1</td>
<td>97.5</td>
<td>98.2</td>
<td>98.4</td>
</tr>
</tbody>
</table>

2. Winding tightness

![How tightly wound do the spiral arms appear?](image)

![graph of vote proportion vs measured pitch angle]
100 galaxy comparison with $\sim 10$ Humans

Pitch Angle

![Graphs showing comparison between Arkansas and Jun Ma with the line y=x as a reference.](image-url)