Multi-Level Image Segmentation via Particle Swarm Optimization

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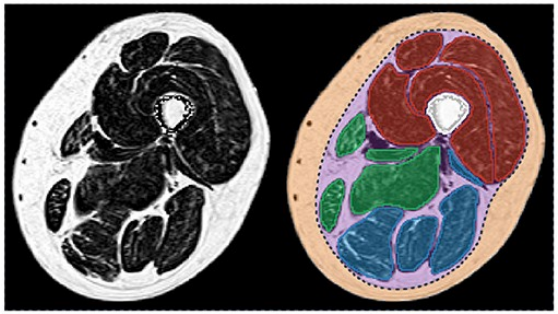
What's the Big Picture? Helping Doctors See Better

- **The Challenge: Seeing Inside with Medical Scans (like MRIs)**
  - Scans show doctors what's happening inside the body.
  - But sometimes, important details can be hard to spot.
- **Our Goal: "Coloring" the Scan to Highlight Different Parts**
  - This is called **Image Segmentation**.
  - It's like drawing outlines around different tissues or areas.
- **How? Brightness "Cut-off Points" (Multi-Level Thresholding)**
  - We tell the computer: "Everything darker than X is one color, between X and Y is another color, and brighter than Y is a third color."
  - Finding the best X, Y, Z... cut-off points is tricky!



My Project: A Smart Search Team for the Best "Cut-off Points"

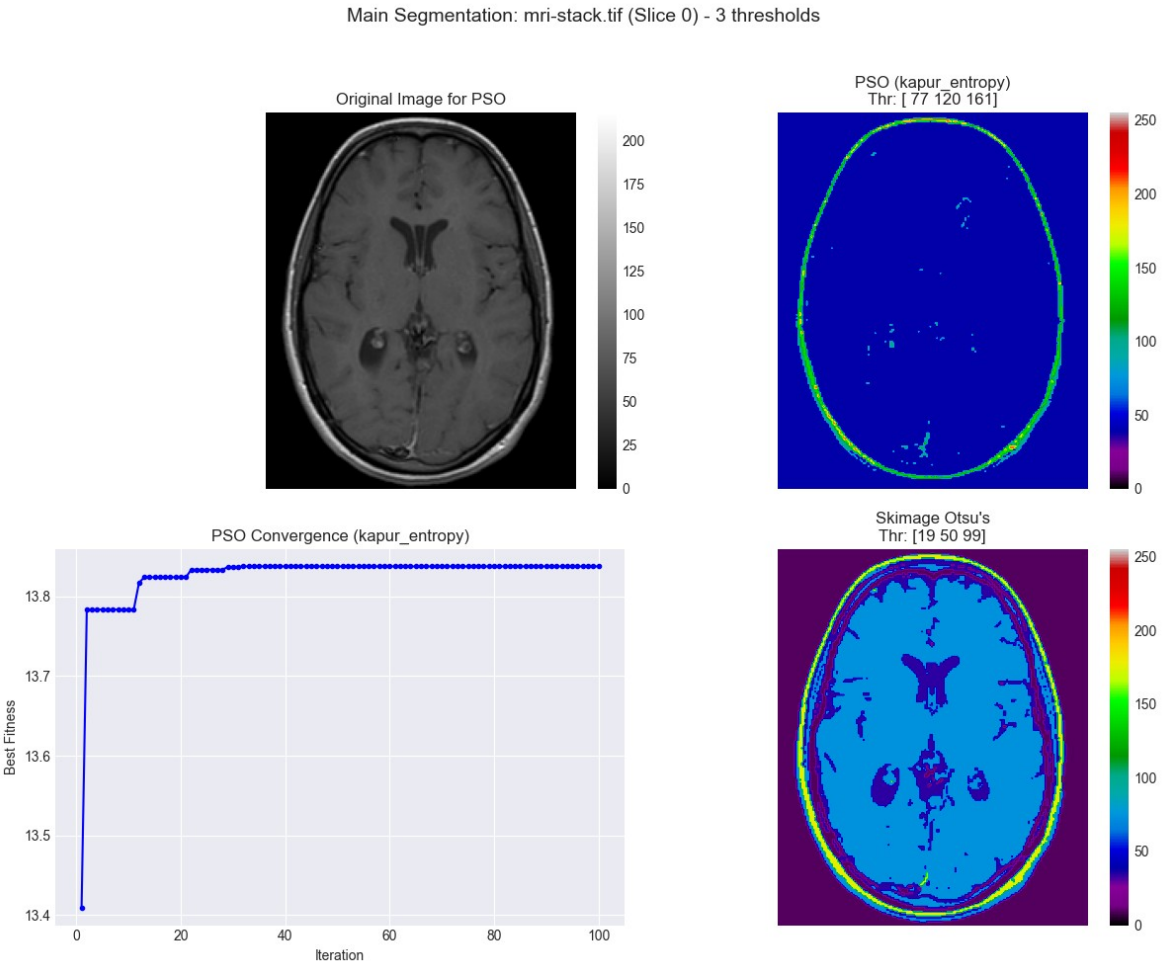
- **My Project's Aim:**
  - Teach a computer to *automatically* find the very best brightness cut-off points for any MRI scan.
- **My Tool: A Digital Search Team called "Particle Swarm Optimization" (PSO)**
  - Imagine tiny digital "explorers" (particles).
  - Each explorer suggests a different set of cut-off points.
  - They work together as a team (a swarm) to find the best possible set.

How the "Search Team" Works & Decides What's "Best"

- **The "Explorers" (Particles):**
  - Each suggests a set of cut-off points (e.g., "cut at brightness 50, 120, 180").
- **Learning & Improving:**
  - Each explorer remembers *its own* best suggestion so far.
  - The whole team knows the *overall best suggestion* found by anyone in the team.
  - They use this to make better suggestions in the next round.
- **The "Goodness Score" (Fitness Function): How we tell if cut-offs are good.**
  - We need a way to score how good each explorer's suggested cut-off points are.
  - **Score #1: Kapur's Entropy** – Aims for "interesting" and "well-separated" colored regions. (High score = good)
  - **Score #2: Otsu's Variance** – Aims for colored regions that are very "different" from each other. (High score = good)
- **Input Image:** We used a special black-and-white version (L* channel) focusing only on brightness.

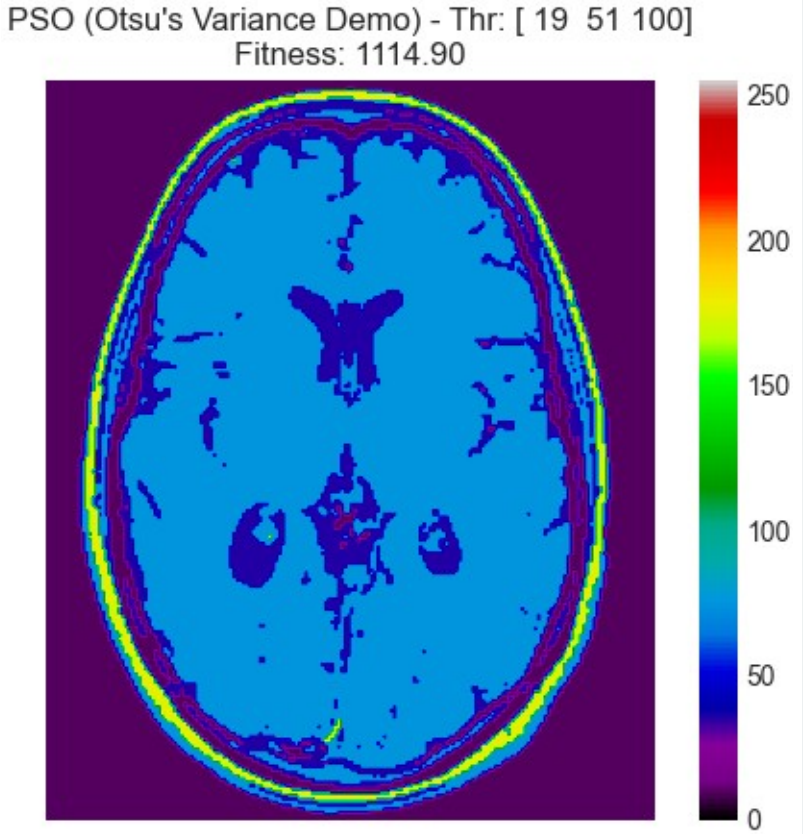
Results - Part 1: Using the "Interesting & Separated" Score (Kapur's)

- **Goal:** Make colored regions "interesting & well-separated" (Kapur's Score)
- **Our PSO Team's Best Cut-offs:** [77, 120, 161] -> **Kapur Score: 13.84**
- **A Standard Method (Skimage Otsu):** Cut-offs [19, 50, 99] -> **Kapur Score: 11.68**
- **Finding:** Our PSO team got a *better* "interesting & separated" score!



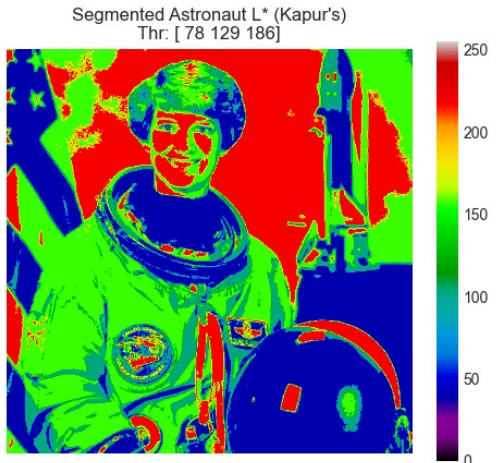
Results - Part 2: Using the "Very Different Regions" Score (Otsu's) - A Sanity Check!

- **Goal:** Make colored regions "very different" from each other (Otsu's Score)
- **Our PSO Team's Best Cut-offs:** [19, 51, 100] -> **Otsu Score: 1114.90**
- **Standard Otsu Method's Cut-offs:** [19, 50, 99] (This method *is designed* to be optimal for this score!)
- **Finding:** Our PSO team found almost the *exact same* cut-off points as the standard method! This means our team is working correctly!



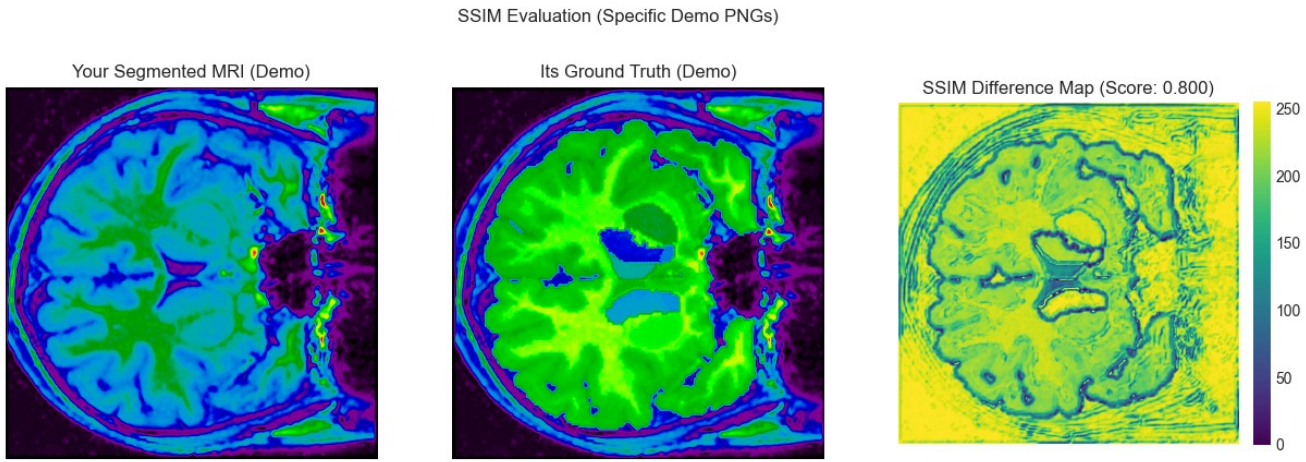
Other Cool Things We Tried

- **1. Working with Color:**
  - We showed we can take a color image and pick out its "lightness" and "brightness" information.
  - This means the same PSO team could work on different kinds of images.



Other Cool Things We Tried

- **2. Checking Against a "Perfect Example" (SSIM Score):**
  - We had a "perfectly colored" example image (called a Ground Truth).
  - We compared our PSO's coloring to it and got a similarity score (SSIM) of **0.800** (out of 1).
  - The "Difference Map" (Figure 4) shows where our coloring matched well and where it was different.



So, What Did We Learn? (Conclusion)

- **Our "Digital Search Team" (PSO) is a good detective for finding hidden details!**
- **Key Discoveries:**
  - When we asked it to make regions "interesting & well-separated" (Kapur's), it did *even better* than a standard method (Score 13.84 vs 11.68).
  - When we asked it to make regions "very different" (Otsu's), it found almost the *exact same best solution* as the standard method designed for that task! (This means our team works right!)
  - The "goodness score" we choose really changes what the final "colored" picture looks like.
- **Plus:** We showed it can handle different image types (like brightness from color) and we can check its work against a "perfect example" (SSIM score 0.8).

What's Next? Making the Search Team Even Better!

- **Smarter Explorers:** Use even more advanced PSO techniques (like the "CIWP-PSO" ideas).
- **Look at Shapes Too:** Teach the team to consider shapes and textures, not *just* brightness.
- **Try New "Goodness Scores":** Explore other ways to define what a "good" coloring is.
- **More Pictures, More Tests:** Try it on many different scans to see how well it works everywhere.
- **Let the Team Decide:** Could the PSO team learn to pick the *right number* of cut-off points by itself?

Thank You & Questions

- **Thank You**
- **Any Questions?**