

INTRODUCTION

- Medical imaging segmentation has undefined image domain size.
- Difficult to evaluate results correctly.
- Most papers utilize Dice(DC) or Jaccard(JC) coefficients to evaluate and compare segmentation results.
- These metrics are unbalanced.
- False negative labeled pixels (i.e. under-segmentation) have a stronger impact on the results than the false positive ones (i.e. over-segmentation).

REGION-BASED METRICS

- O – Ground-truth object pixel set.
- O_m – Segmentation object pixel set with method m .
- B – Ground-truth background pixel set.
- B_m – Segmentation background pixel set with method m .

$$TP = O \cap O_m \quad JC = \frac{|TP|}{|TP| + |FP| + |FN|} \quad [1]$$

$$TN = B \cap B_m \quad DC = \frac{2|TP|}{2|TP| + |FP| + |FN|} \quad [2]$$

$$FP = B \cap O_m \quad BJC = \frac{|TP|}{|TP| + |FN| + |FP| + \frac{|FP|}{|TP| + |FN|}} \quad [3]$$

$$FN = O \cap B_m \quad BDC = \frac{2|TP|}{2|TP| + |FN| + |FP| + \frac{|FP|}{|TP| + |FN|}} \quad [3]$$

PROPOSED METRIC

- Idea: minimize expression $(|O| - |FP|)(|O| - |FN|)$, which is balanced.
- Normalizing: $GBC = \frac{(|O| - |FP|)(|O| - |FN|)}{|O|^2}$
- Utilizing Polylogarithm function Li_0 when $|FP| \leq |O|$:

$$GJC = \frac{|TP|}{|TP| + |FN| + \sum_{i=0}^{+\infty} \frac{|FP|^{i+1}}{|O|^i}}$$

- Generalizing:

$$GB(\delta) = \frac{\delta |TP|}{\delta |TP| + |FN| + \sum_{i=0}^{+\infty} \frac{|FP|^{i+1}}{|O|^i}}$$

METRICS RELATIONSHIP

- Computing an approximation of GB:

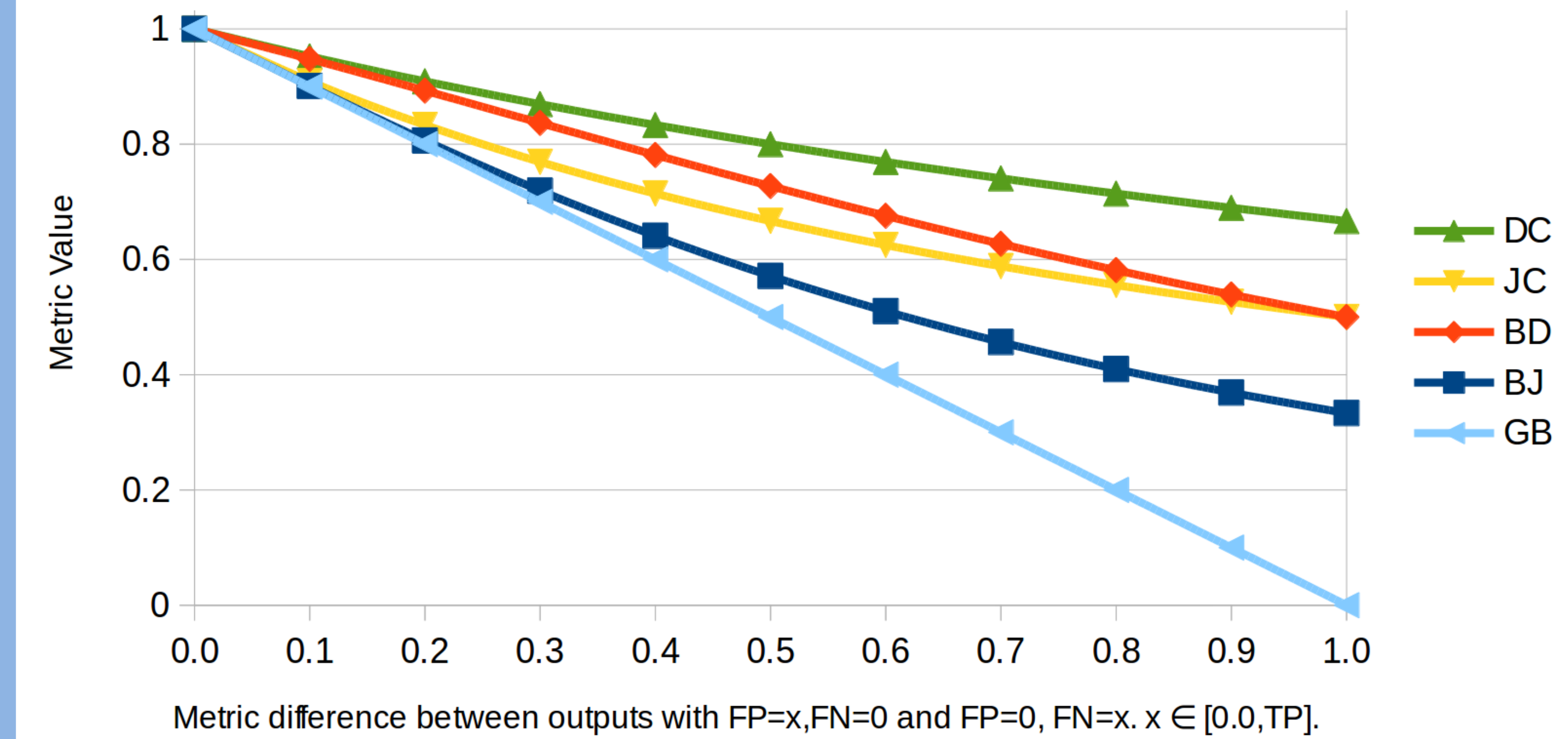
$$GB_n(\delta) = \frac{\delta |TP|}{\delta |TP| + |FN| + \sum_{i=0}^n \frac{|FP|^{i+1}}{|O|^i}}$$

- Setting $n=0, \delta=1 \rightarrow GB_0(1)=JC$
- Setting $n=0, \delta=2 \rightarrow GB_0(2)=DC$
- Setting $n=1, \delta=1 \rightarrow GB_1(1)=BJC$
- Setting $n=1, \delta=2 \rightarrow GB_1(2)=BDC$

REFERENCES

- [1] LR Dice, *Measures of the amount of ecologic association between species*, Ecology, vol. 26, pp. 297–302, 1945.
- [2] P Jaccard, *Étude comparative de la distribution florale dans une portion des alpes et des jura*, Bulletin del la Société Vaudoise des Sciences Naturelles, vol. 37, pp. 547–579, 1901.
- [3] FAM Cappabianco, PAV de Miranda, and JK Udupa, *A critical analysis of the methods of evaluating mri brain segmentation algorithms*, ICIP 2017, pp. 3894–3898

BEHAVIOR



EXPERIMENTS

	BRAIN			BRAIN W/O STEM		
	PVC	FAST	OPF	PVC	FAST	OPF
JC	0.77±0.09	0.79±0.03	0.69±0.09	0.78±0.09	0.80±0.03	0.71±0.09
BJC	0.74±0.14	0.78±0.04	0.69±0.09	0.75±0.14	0.78±0.04	0.70±0.08
GB(1)	0.71±0.20	0.77±0.04	0.69±0.09	0.72±0.20	0.78±0.04	0.70±0.08
DC	0.87±0.07	0.88±0.02	0.81±0.06	0.87±0.07	0.89±0.02	0.82±0.06
BDC	0.84±0.11	0.87±0.03	0.81±0.06	0.85±0.11	0.88±0.03	0.82±0.06
GB(2)	0.81±0.18	0.87±0.03	0.81±0.06	0.82±0.17	0.87±0.03	0.82±0.06

Evaluation of PVC, FAST, and OPF for WM segmentation. IBSR dataset (Mean±Standard deviation)

RESULTS

- New metric that is completely balanced.
- Based on intuitive expression.
- Generalizes Jaccard, Dice, Balanced Jaccard and Dice metrics.
- Truly changes the interpretation of experiments.