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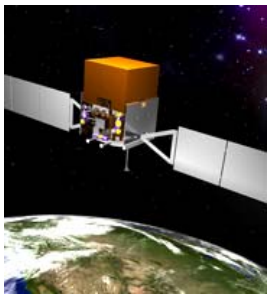

Creating Decision Trees for GLAST analysis: A new C++-based procedure

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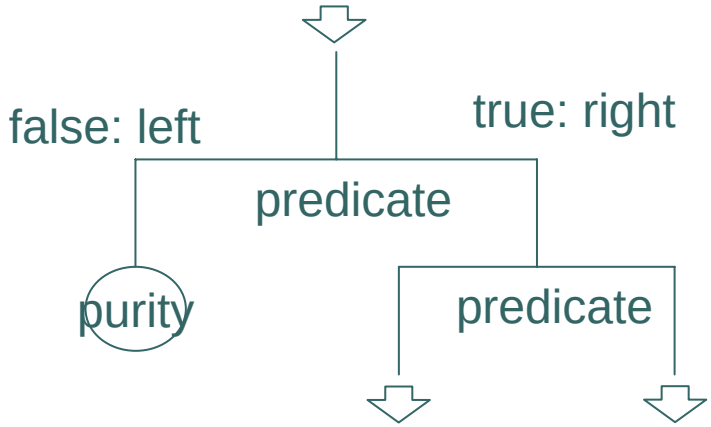
Outline

- Quick review of classification (or decision) trees
- Training and testing
- How Bill does it with Insightful Miner
- Application to the “good-gamma” trees: how does it compare?

Quick Review of Decision Trees

- Introduced to GLAST by Bill Atwood, using InsightfulMiner
- Each branch **node** is a predicate, or cut on a variable, like *CalCsIRLn > 4.222*
- If true, this defines the **right** branch, otherwise the left branch.
- If there is no branch, the node is a **leaf;** a leaf contains the **purity** of the sample that reaches that point
- Thus the tree defines a function of the event variables used, returning a value for the purity from the training sample



Training and testing procedure

- Analyze a training sample containing a mixture of “good” and “bad” events: I use the *even* events
- Choose set of variables and find the optimal cut for such that the left and right subsets are purer than the orignal. Two standard criteria for this: “Gini” and entropy. I currently use the former.
  - W_S : sum of signal weights
  - W_B **:** sum of background weights

  Gini = 2 W_S W_B/(W_S +W_B)

  Thus Gini wants to be small.

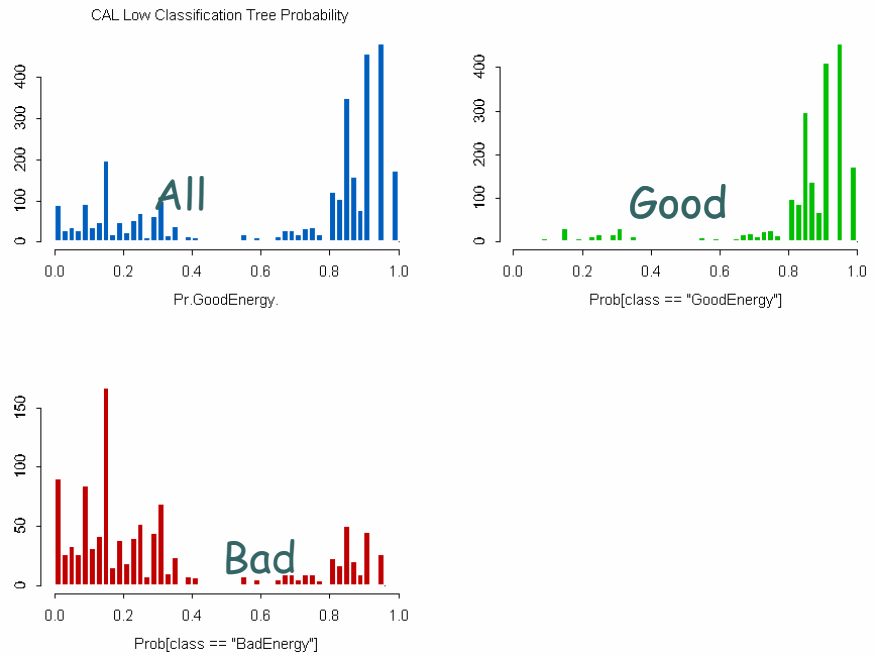
  Actually maximize the *improvement*:
  Gini(parent)-Gini(left child)-Gini(right child)
- Apply this recursively until too few events. (100 for now)
- Finally *test* with the *odd* events: measure purity for each node

Evaluate by Comparing with Bill

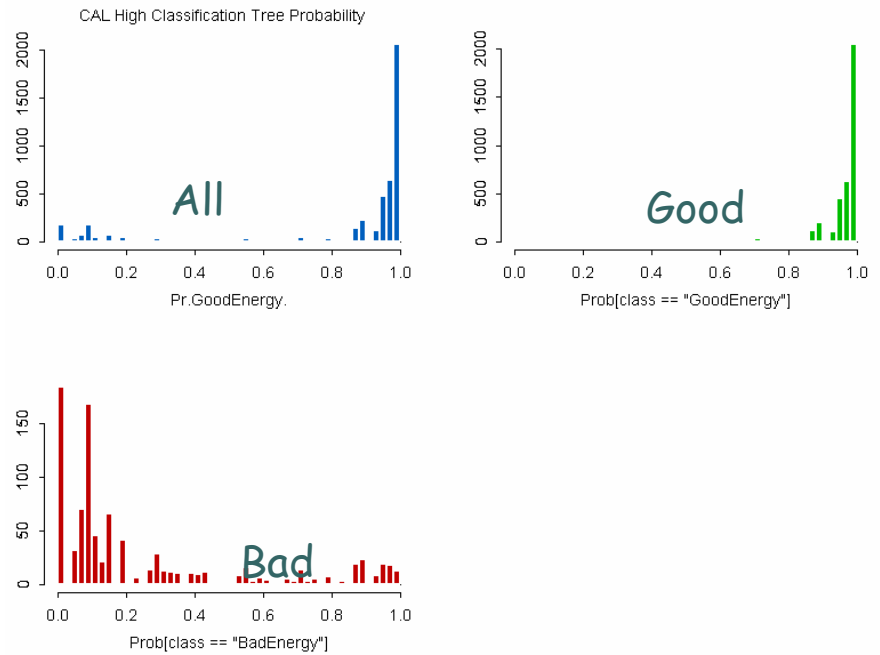
From Bill's Rome '03 talk:

The "good cal" analysis

CAL-Low CT Probabilities



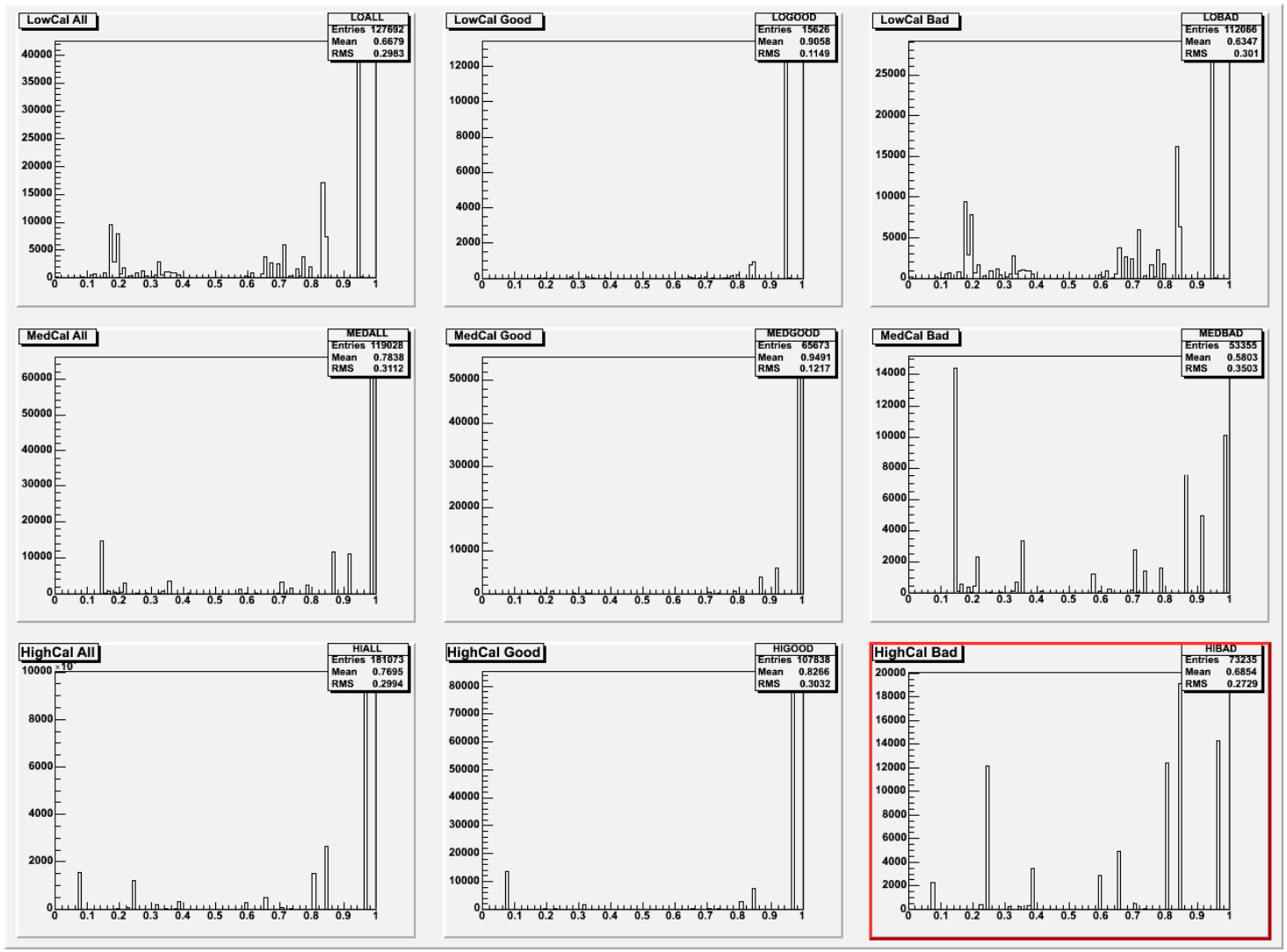
CAL-High CT Probabilities



Compare with Bill, cont

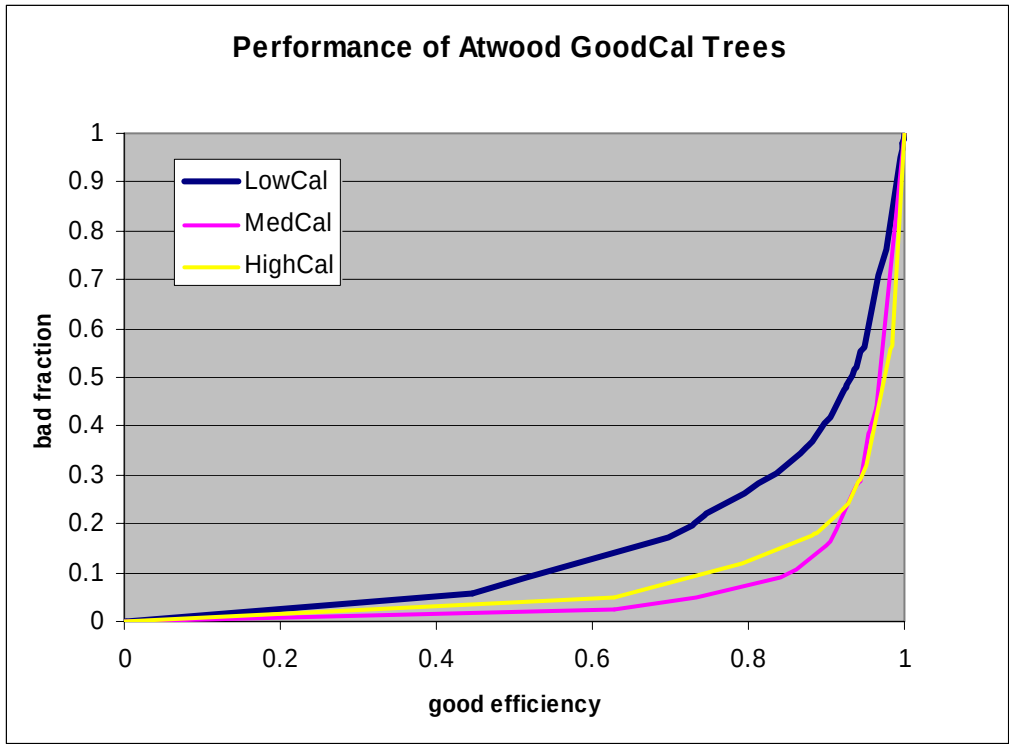
- Since Rome:
  - Three energy ranges, three trees.
    - CalEnergySum: 5-350; 350-3500; >3500
  - Resulting classification trees implemented in Gleam by a “classification” package: results saved to the IMgoodCal tuple variable.
- Data set for training, comparison: the all_gamma from v4r2
  - 760 K events E from 16 MeV to 160 GeV (uniform in log(E), and $0 < \theta < 90$ (uniform in $\cos(\theta)$).
  - Contains IMgoodCal for comparison

Bill-type plots for all_gamma



Another way of looking at performance

Define efficiency as fraction of good events after given cut on node purity; determine bad fraction for that cut



The new *classifier* package

- Properties
  - Implements Gini separation (entropy on todo list)
  - Reads ROOT files
  - Flexible specification of variables to use
  - Simple and compact ascii representation of decision trees
  - Not (yet) implemented: multiple trees, pruning
- Currently in users/burnett, I plan, after suitable notification, to copy it to the cvs root.

Growing trees

- For simplicity, run a *single* tree: initially try *all* of Bill's classification tree variables: list at right.
- The run over the full 750 K events, trying each of the 70 variables takes only a few minutes!

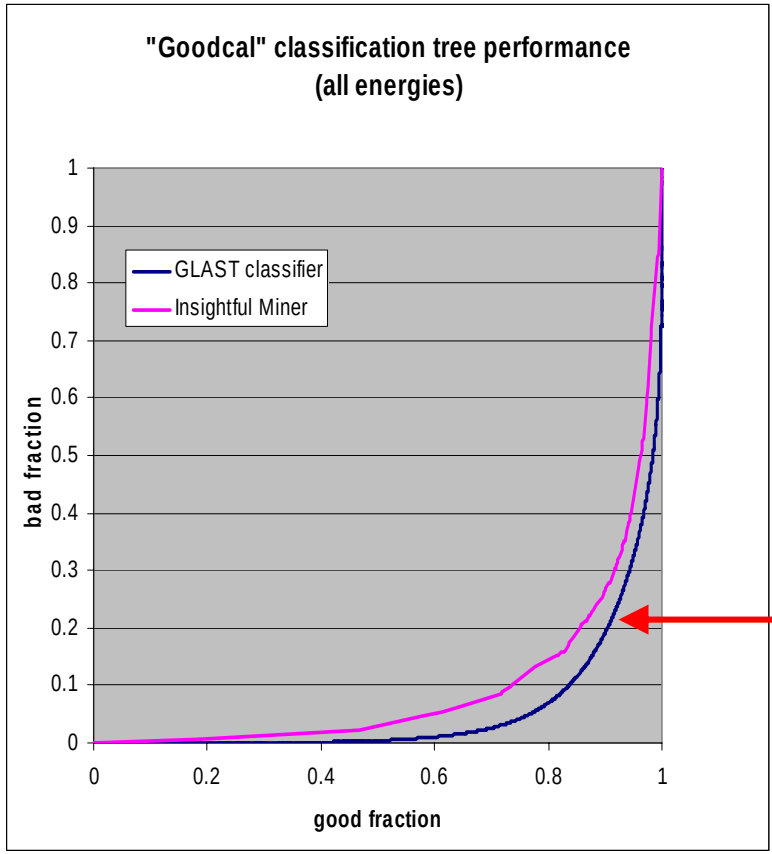
"AcdActiveDist", "AcdTotalEnergy", "CalBkHalfRatio", "CalCsIRLn", "CalDeadTotRat", "CalDeltaT",
"CalEnergySum", "CalLATEdge", "CalLRmsRatio", "CalLyr0Ratio", "CalLyr7Ratio", "CalMIPDiff",
"CalTotRLn", "CalTotSumCorr", "CalTrackDoca", "CalTrackSep", "CalTwrEdge", "CalTwrGap",
"CalXtalRatio", "CalXtalsTrunc", "EvtCalETLRatio", "EvtCalETrackDoca", "EvtCalETrackSep",
"EvtCalEXtalRatio", "EvtCalEXtalTrunc", "EvtCalEdgeAngle", "EvtEnergySumOpt", "EvtLogESum",
"EvtTkr1EChisq", "EvtTkr1EFirstChisq", "EvtTkr1EFrac", "EvtTkr1EQual", "EvtTkr1PSFMdRat",
"EvtTkr2EChisq", "EvtTkr2EFirstChisq", "EvtTkrComptonRatio", "EvtTkrEComptonRatio",
"EvtTkrEdgeAngle", "EvtVtxEAngle", "EvtVtxEDoca", "EvtVtxEEAngle", "EvtVtxEHeadSep",
"Tkr1Chisq", "Tkr1DieEdge", "Tkr1FirstChisq", "Tkr1FirstLayer", "Tkr1Hits",
"Tkr1KalEne", "Tkr1PrjTwrEdge", "Tkr1Qual", "Tkr1TwrEdge", "Tkr1ZDir", "Tkr2Chisq", "Tkr2KalEne",
"TkrBlankHits", "TkrHDCount", "TkrNumTracks", "TkrRadLength", "TkrSumKalEne", "TkrThickHits",
"TkrThinHits", "TkrTotalHits", "TkrTrackLength", "TkrTwrEdge", "VtxAngle", "VtxDOCA", "VtxHeadSep",
"VtxS1", "VtxTotalWgt", "VtxZDir"

Performance of the truncated list

1691 leaf nodes

3381 total

Name	improvement
CalCsIRLn	21000
CalTrackDoca	3000
AcdTotalEnergy	1800
CalTotSumCorr	800
EvtCalEXtalTrunc	600
EvtTkr1EFrac	560
CalLyr7Ratio	470
CalTotRLn	400
CalEnergySum	370
EvtLogESum	370
EvtEnergySumOpt	310
EvtTkrEComptonRatio	290
EvtCalETrackDoca	220
EvtVtxEEAngle	140



Note: this is cheating: evaluation using the same events as for training

Plans

- Implement multiple trees:
  - “boosting”
  - Averaging
- Try *truncation* to reduce size of tree without losing performance
- This is only one of Bill’s variables: also need trees for:
  - PSF tail reduction
    - But we do not implement “regression trees”
  - vertex choice: one track or vertex
  - good-gamma prediction