# Decoding Times of Irregular Gallager Codes

David J. C. MacKay

Department of Physics, University of Cambridge

Cavendish Laboratory, Madingley Road,
Cambridge, CB3 0HE, United Kingdom.

`mackay@mrao.cam.ac.uk`

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### Abstract

This paper is an appendix to *'Comparison of Constructions of Irregular Gallager Codes'* by David J. C. MacKay, Simon T. Wilson and Matthew C. Davey, which was published in the proceedings of the 1998 Allerton Conference on Communication, Control, and Computing and submitted to IEEE Transactions on Communications 30 July 1998. That paper compares alternative methods for constructing irregular Gallager codes.

This paper reports the decoding times of the codes studied in that paper. The decoding time differs very little between irregular codes and regular codes.

I prepared this draft for Dan Spielman. Dan, should I write this up for publication somewhere? Perhaps in the *IEEE Transactions on Sparse Graph Codes*? Oh, that doesn't exist yet does it.

## 1   Introduction

It is natural to speculate that irregular Gallager codes might take longer to decode than regular Gallager codes. This paper presents the facts, for the case of a small collection of well–studied codes.

The decoding time can be described by the number of iterations of the sum–product algorithm required. One iteration is a horizontal step followed by a vertical step. Given one code and a set of channel conditions the decoding time varies randomly from trial to trial. Figure 1 shows two histograms of the number of iterations to get a valid decoding under two channel conditions. (Cases where no valid decoding was found are not included in the histograms.) When the signal to noise ratio is higher, fewer iterations are required. In the remaining figures in this paper histograms like these are summarised by five percentiles: the 5th, 25th, 50th (also known as the median), 75th, and 95th.

## 2   Decoding times

In each panel, the bottom graph shows for one code of each construction the median number of iterations to get a successful decoding as a function of $E_b/N_0$; upper and lower bars show the 5th, 25th, 75th and 95th percentiles of the number of iterations.
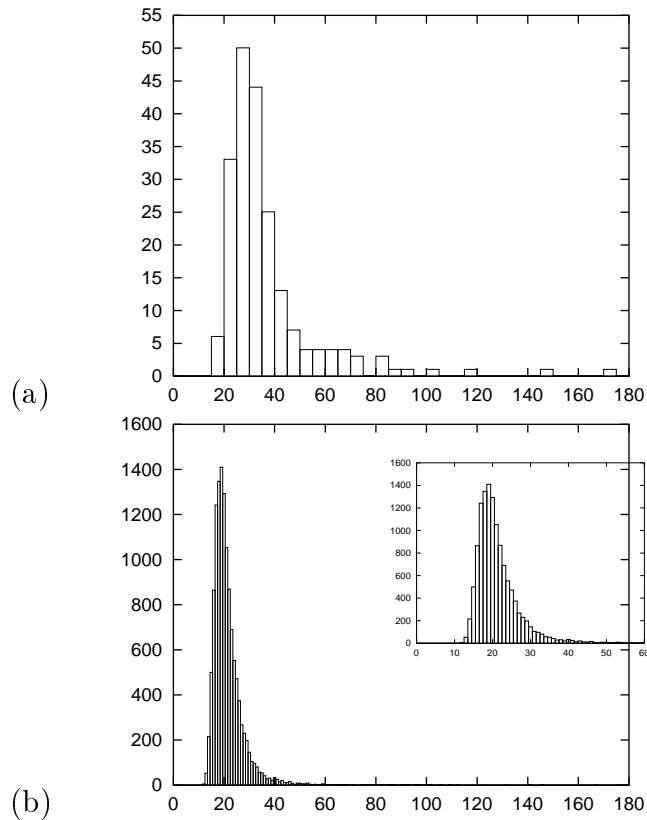
(a)

(b)

Figure 1: Histogram of number of iterations for a regular Gallager code with transmitted block length $N = 9972$ and rate $R = 1/2$. (a) Channel signal to noise ratio $x/\sigma = 1.15$. (b) $x/\sigma = 1.18$.
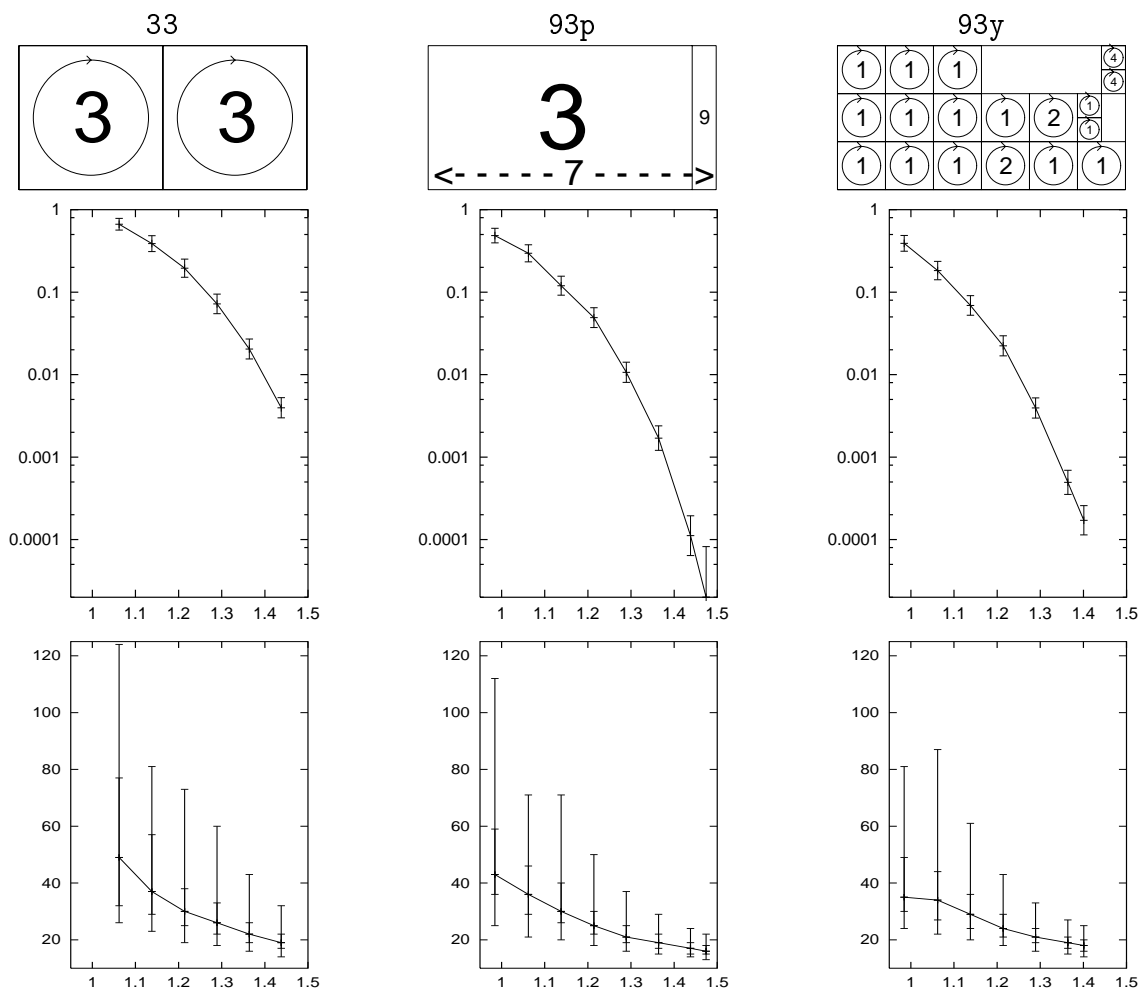
Figure 2: Upper panels: constructions of regular and irregular codes. Lower panels: performance of these codes. The construction types shown are regular, (33), Poisson (93p), and super–Poisson (93y).

Notation for upper panels for all constructions except 93p: an integer represents a number of permutation matrices superposed on the surrounding square. Horizontal and vertical lines indicate the boundaries of the permutation blocks. Notation for the Poisson construction 93p: integers '3' and '9' represent column weights. The integer '7' represents the row weight.

Lower panels show the performance of several random codes of each construction. Vertical axis: block error probability. Horizontal axis: $E_b/N_0$ in dB. All codes have $N = 9972$, and $K = M = 4986$.

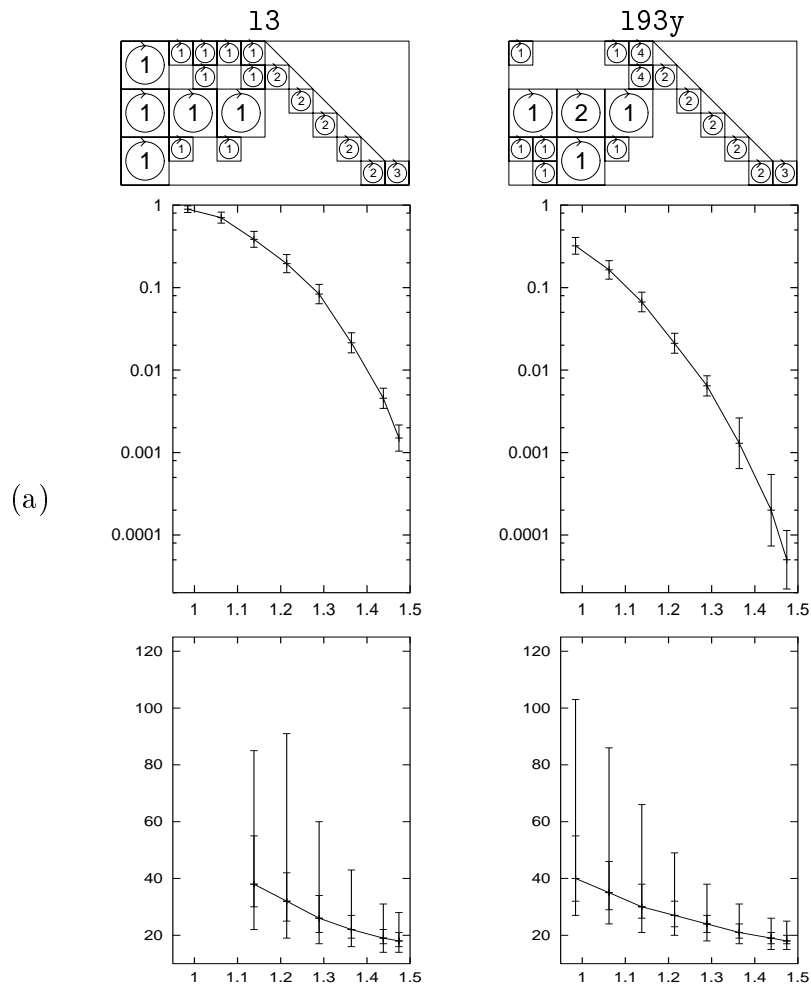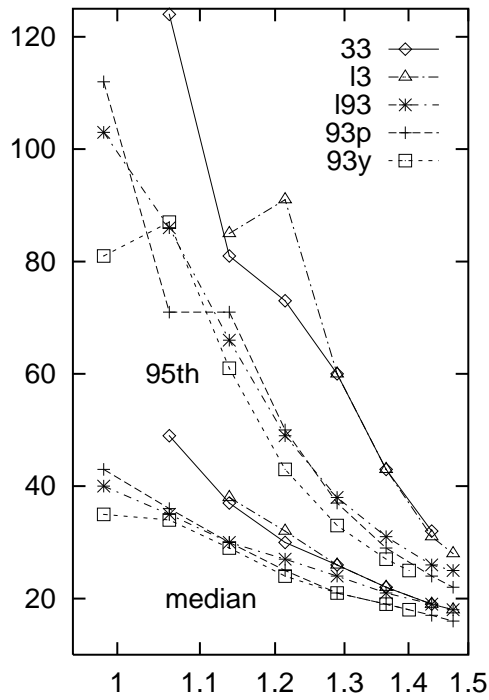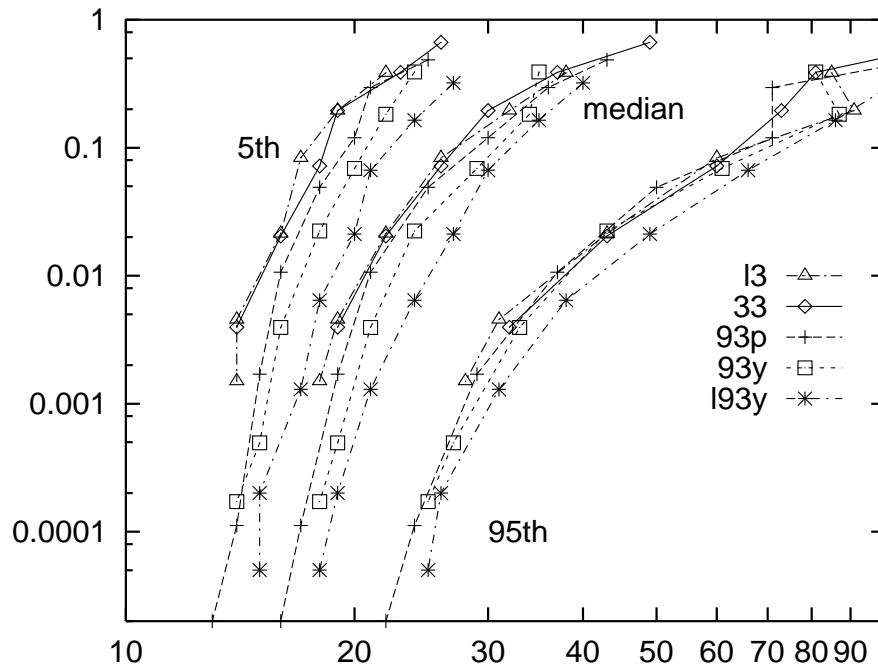All errors were detected errors, as is usual with Gallager codes.

Figure 3: (a) Upper panels: construction methods `l3` and `l93y`. As in figure 2, an integer represents a number of permutation matrices superposed on the surrounding square. A diagonal line represents an line of 1s. Horizontal and vertical lines indicate the boundaries of the permutation blocks. Lower pictures: Variability of performance among `l3` and `l93y` codes. Vertical axis: block error probability. Horizontal axis: $E_b/N_0$ in dB.

Figure 4: (a) Number of iterations versus $E_b/N_0$. (b) Error probability versus number of iterations (on log scale). Curves show 5th, 50th and 95th percentiles for codes with five different constructions.

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