

NC STATE UNIVERSITY  
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING  
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## Project 2: Branch Prediction

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# 1 EXPLORING THE BIMODAL PREDICTOR

## 1.1 PLOT 1

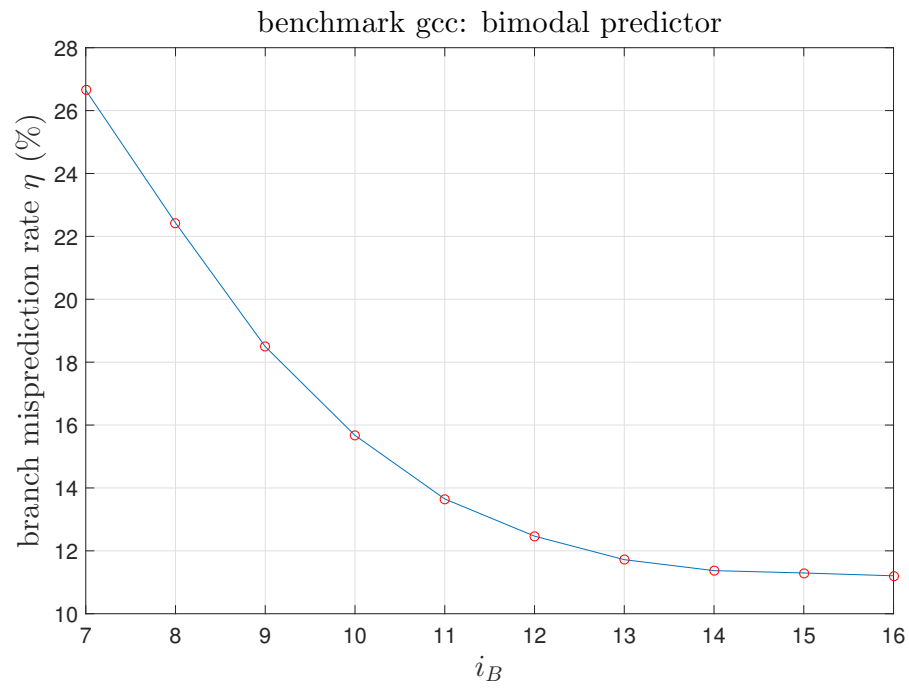


Figure 1.1: Bimodal Predictor Performance in benchmark gcc

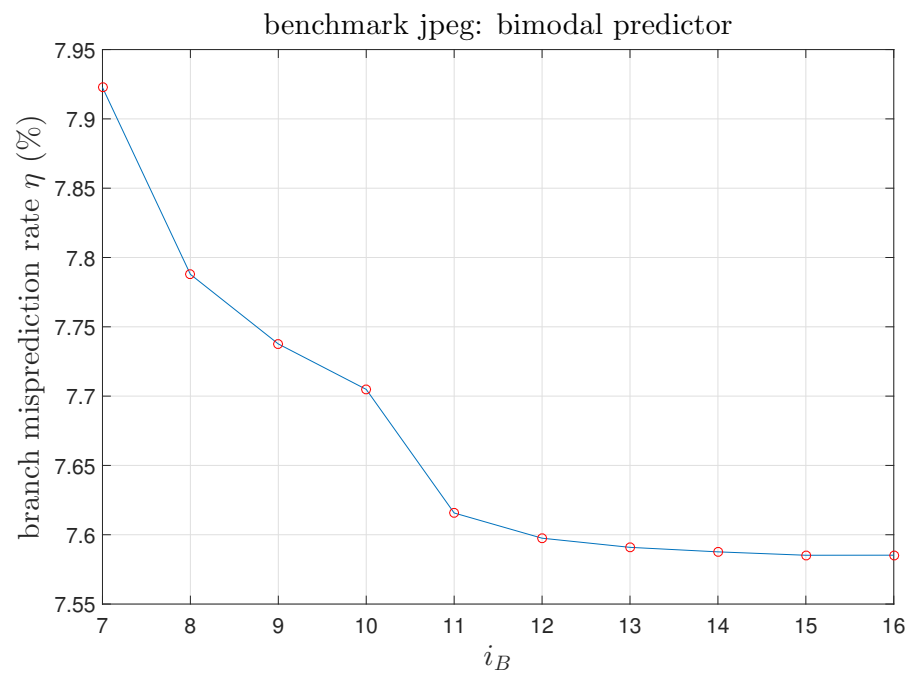


Figure 1.2: Bimodal Predictor Performance in benchmark jpeg

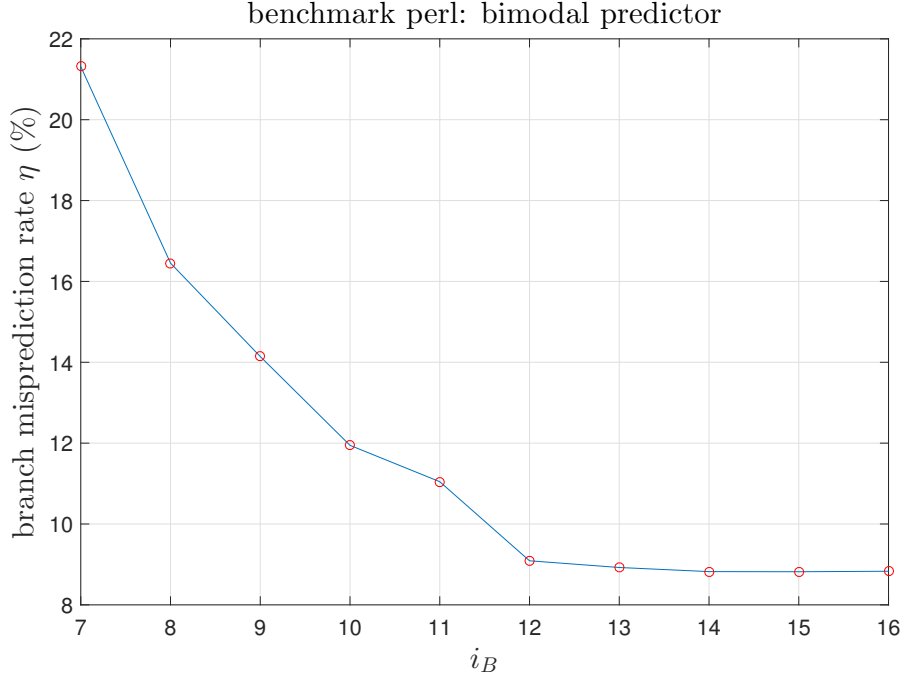


Figure 1.3: Bimodal Predictor Performance in benchmark perl

## 1.2 ANALYSIS

From Figure 1.1, 1.2 and 1.3, we have observations that branch misprediction rate decreases, nearly exponentially, as the index width,  $i_B$ , increases of which index in PC is used to index the counters in bimodal predictor. Because different branches may index the same entry in the prediction table, which is called "interference", the longer the index is, the smaller the side-effect of interference is and thus the smaller the misprediction rate is. However, after a certain value of  $i_B$ , the descending of misprediction rate slows down - diminishing returns. From Figure 1.1, 1.2 and 1.3, the point is  $i_B = 12$ .

## 1.3 DESIGN

In order to take both misprediction rate and size in to consideration, **production of misprediction rate square and square root of size** of a bimodal predictor is defined as follows,

$$\text{production of misprediction rate square and square root of size} = \text{misprediction rate}^2 \times \sqrt{\text{predictor storage size}} \quad (1.1)$$

Apparently, the smaller production is, the better predictor is.

Figure 1.4 shows the production of misprediction rate square and square root of size of bimodal predictor under different benchmarks and their average.

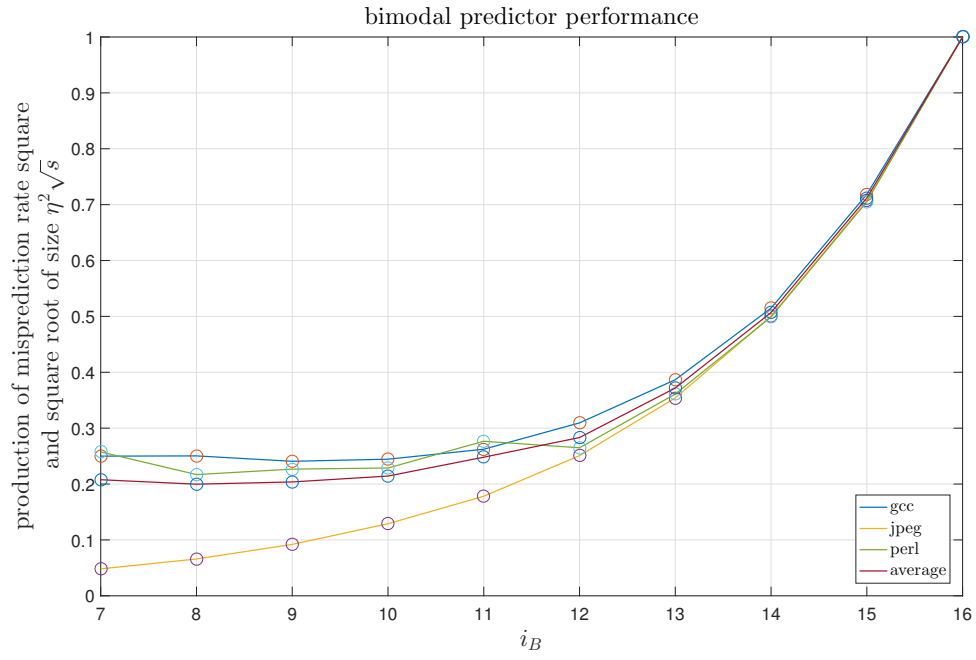


Figure 1.4: Bimodal Predictor Performance (after normalization)

From the average line in the Figure 1.4, before the diminishing returns ( $i_B = 12$ ), the production of misprediction rate square and square root of size is nearly flat, and therefore I'll choose  $i_B = 10$  or  $i_B = 12$  as final design of bimodal predictor.

## 2 EXPLORING THE GSHARE PREDICTOR

### 2.1 PLOT 2

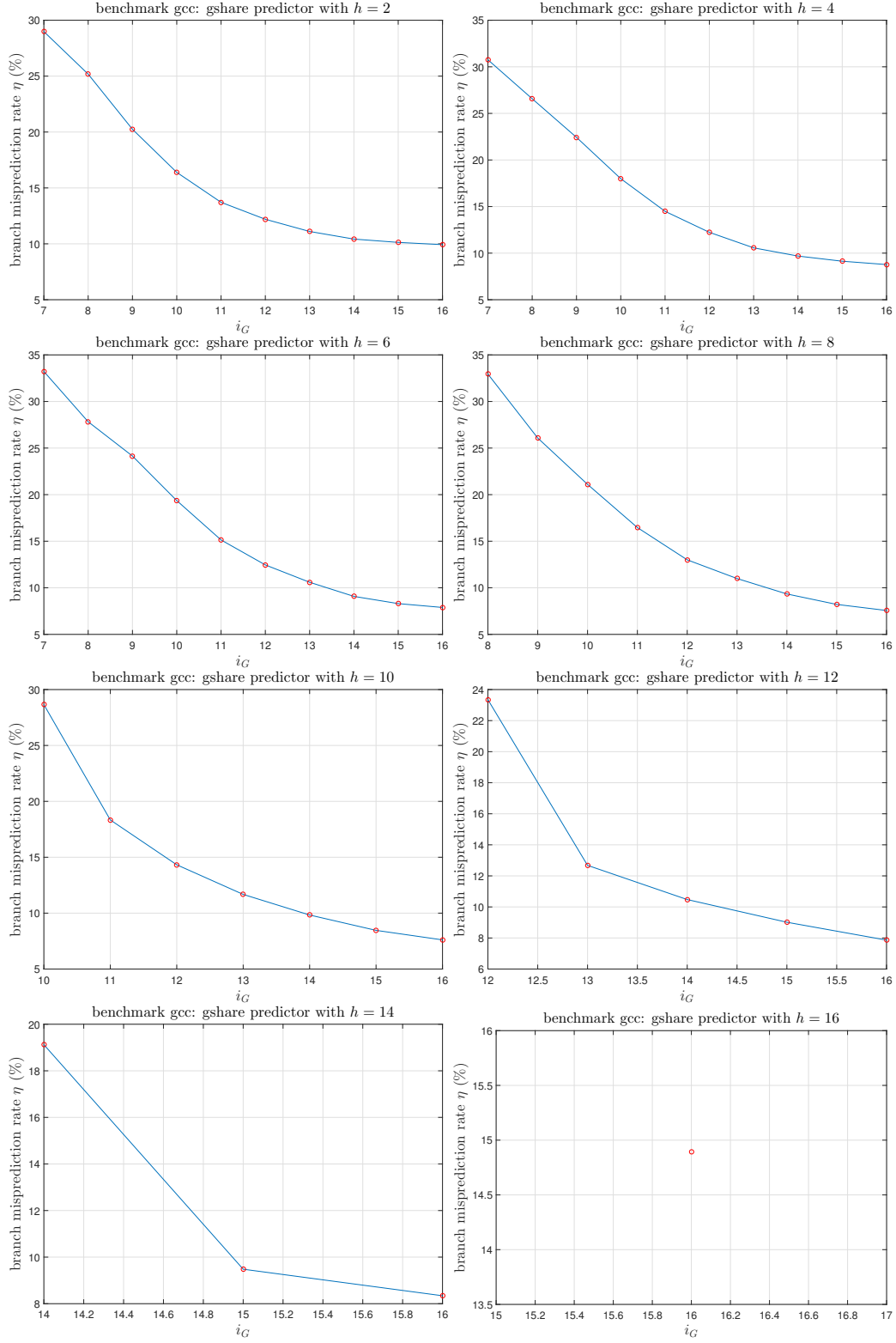


Figure 2.1: Gshare Predictor Performance in benchmark gcc

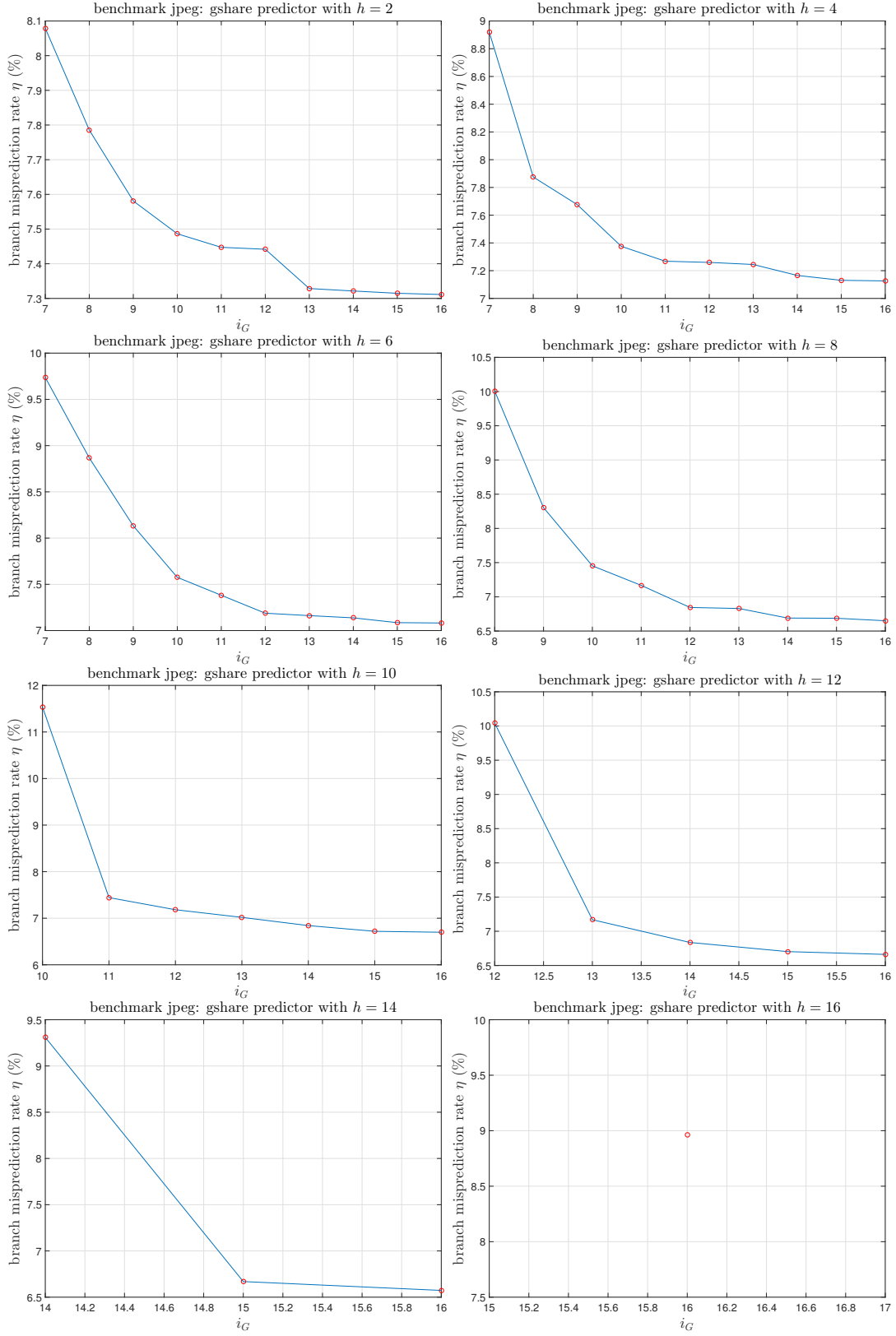


Figure 2.2: Gshare Predictor Performance in benchmark jpeg

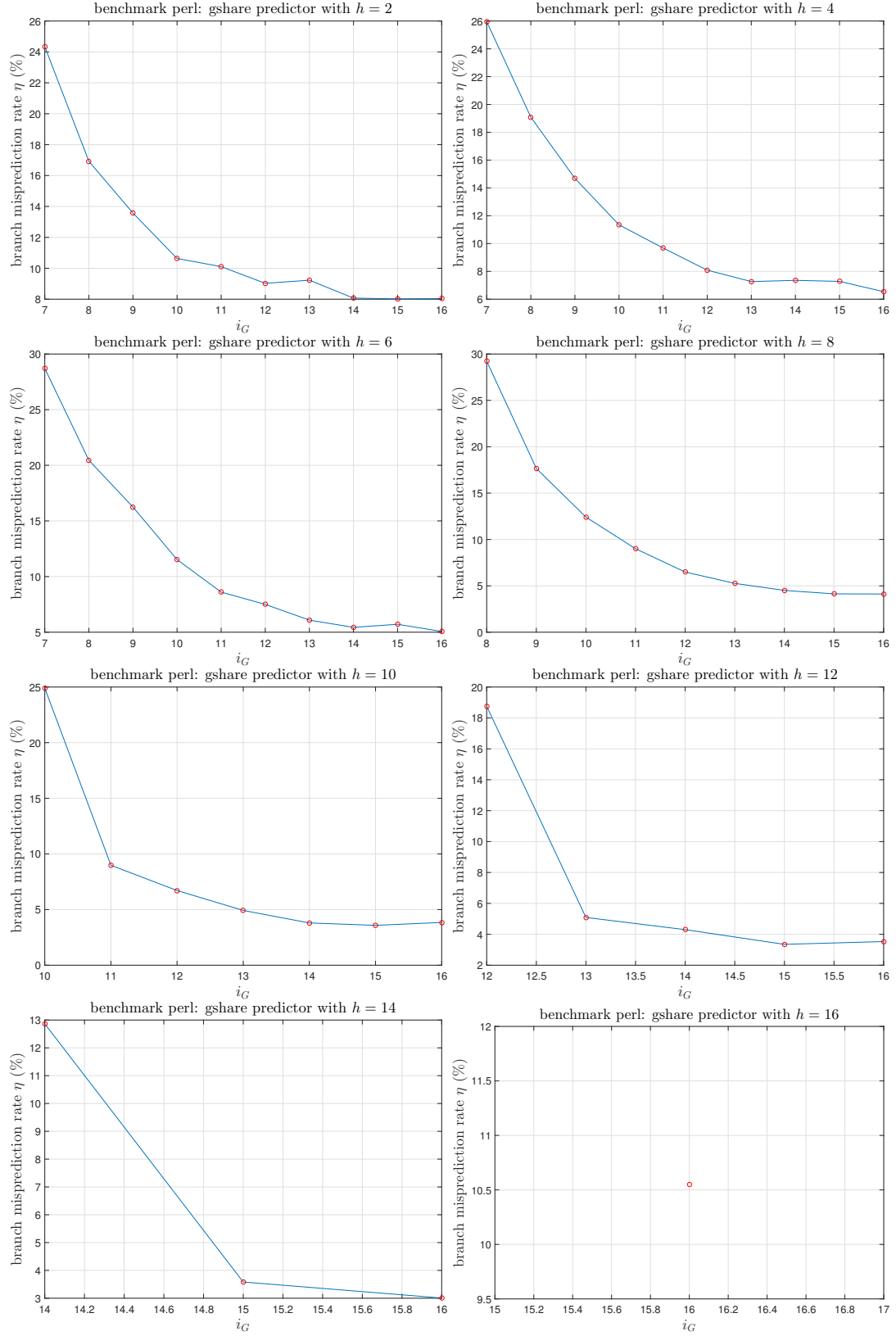


Figure 2.3: Gshare Predictor Performance in benchmark perl



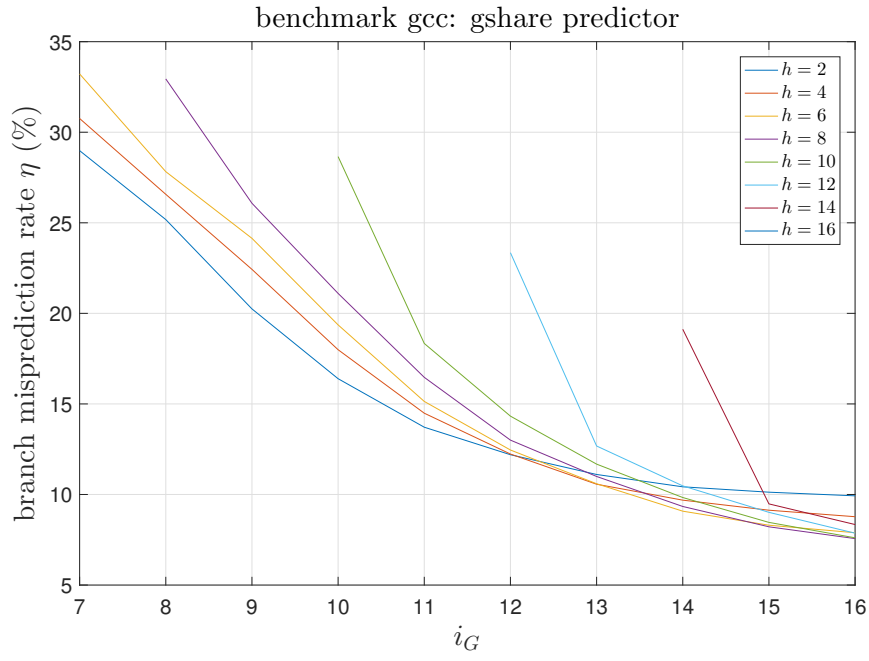


Figure 2.4: Gshare Predictor Performance in benchmark gcc

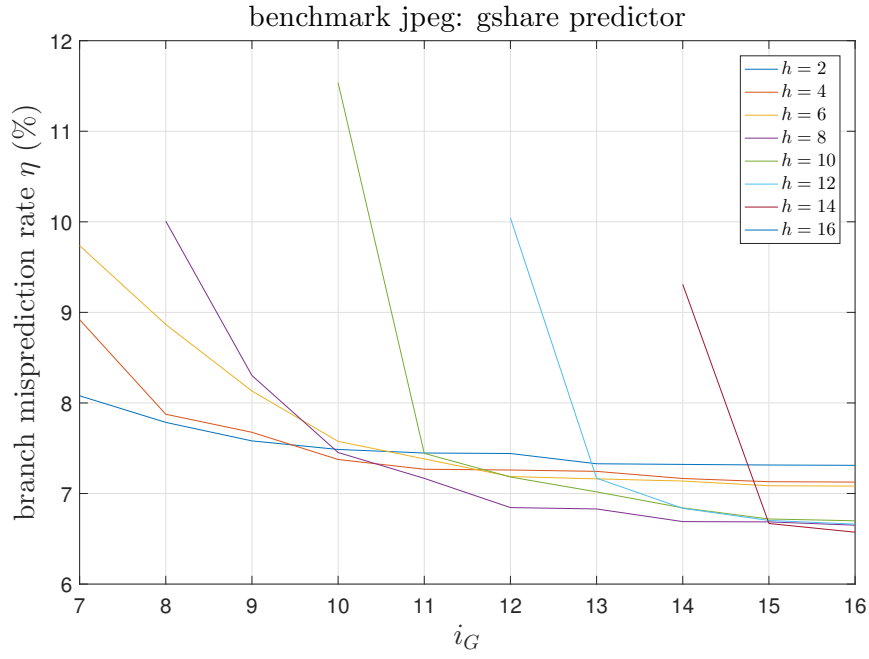


Figure 2.5: Gshare Predictor Performance in benchmark jpeg

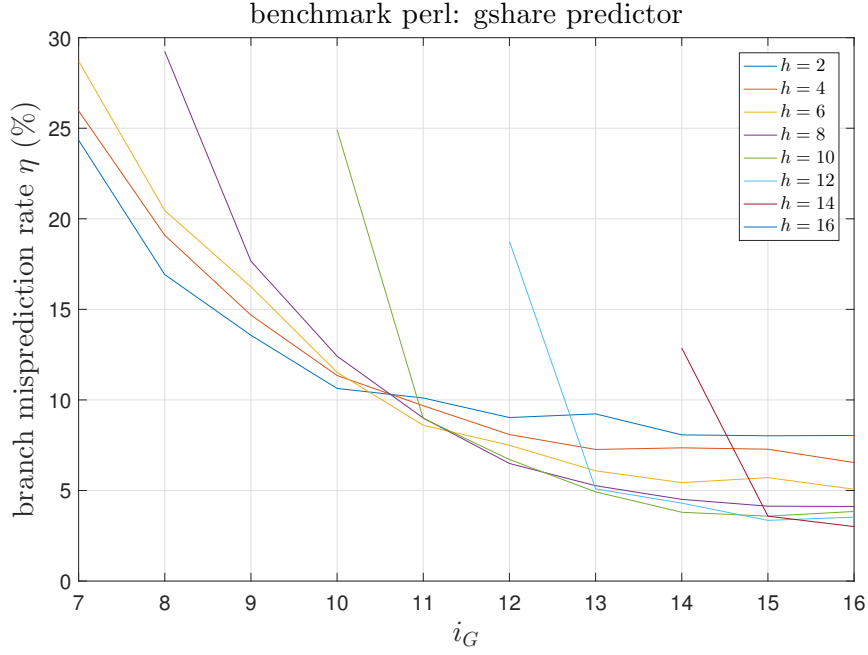


Figure 2.6: Gshare Predictor Performance in benchmark perl

## 2.2 ANALYSIS

From Figure 2.1, 2.2 and 2.3, we have observations that branch misprediction rate decreases, nearly exponentially, as the index width,  $i_G$ , increases in gshare predictor. The reason may be the same as that of bimodal predictor, which is "interference". However, after a certain value of  $i_B$ , the descending of misprediction rate slows down - diminishing returns. From Figure 2.1, 2.2 and 2.3, the point is  $i_G = 12$  for most  $h < 12$ .

In Figure 2.4 (benchmark gcc), higher length of global history register,  $h$ , yields a higher misprediction rate before diminishing returns but yields a lower misprediction rate after diminishing returns. It is more reasonable to observe the relationship between misprediction rate and ratio  $h/i_G$ . From 2.4, generally, smaller  $h/i_G$  yields a lower misprediction rate. Besides, the speeds of descending of misprediction rate versus  $i_G$  are nearly the same among different  $h$ .

In Figure 2.5 (benchmark jpeg), smaller ratio  $h/i_G$  yields a lower misprediction rate, which is same as Figure 2.4. However, in Figure 2.5, the speed of descending of misprediction rate versus  $i_G$  increases as  $h$  increases.

Figure 2.6 (benchmark perl) looks like the combination of Figure 2.4 and Figure 2.5. Smaller ratio  $h/i_G$  yields a lower misprediction rate. Besides, the speed of descending of misprediction rate versus  $i_G$  increases as  $h$  increases.

## 2.3 DESIGN

The concept of **production of misprediction rate square and square root of size** is used again here.

Figure 2.7 shows the production of misprediction rate square and square root of size of gshare predictor under different benchmarks.

Figure 2.8 shows average production of misprediction rate square and square root of size of gshare predictor.

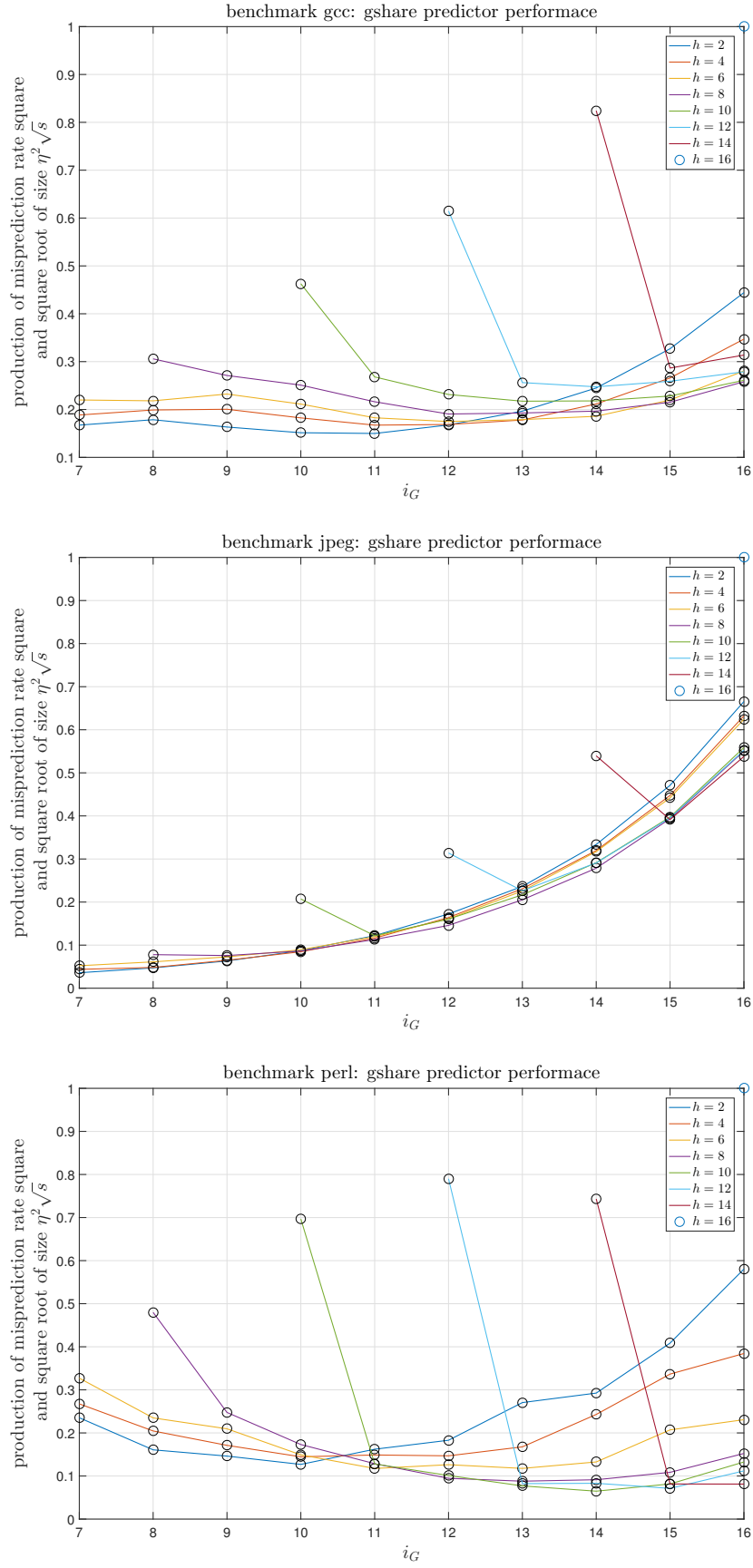


Figure 2.7: Gshare Predictor Performance in different benchmarks (after normalization)

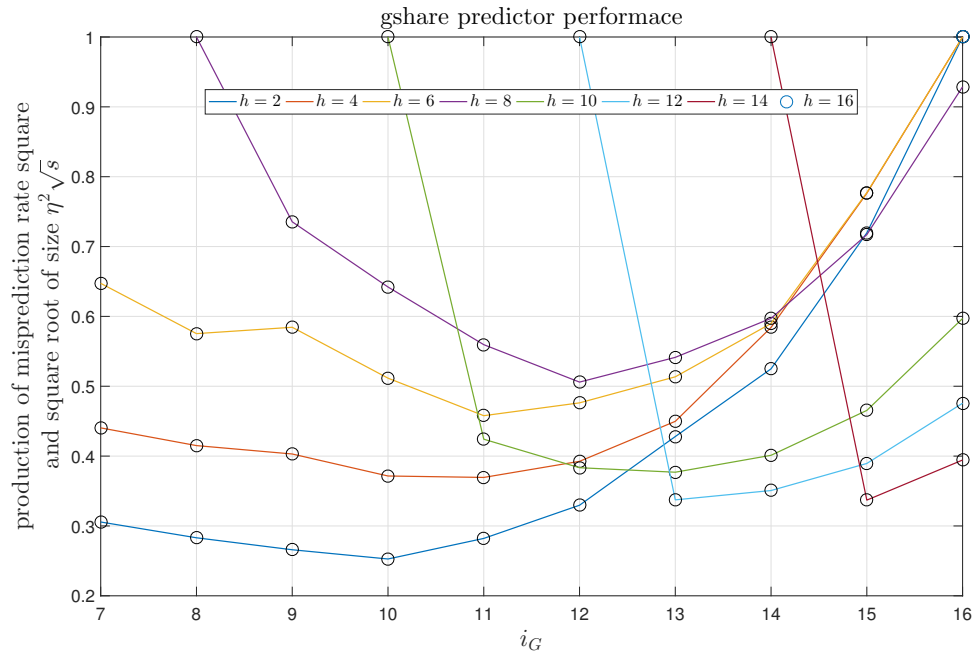


Figure 2.8: Gshare Predictor Performance (after normalization)

Because the smaller the production is, the better the predictor is, and from Figure 2.8, I'll choose  $i_G = 10$  and  $h = 2$  as my design of gshare predictor.

### 3 EXPLORING THE BRANCH TARGET BUFFER

#### 3.1 C CODE

The C code of branch target buffer is provided in **btb.h** and **btb.c**.

### 4 EXPLORING THE HYBRID PREDICTOR

#### 4.1 C CODE

The C code of branch chooser table is provided in **bct.h** and **bct.c**. The C code of hybrid predictor is provided in **bp.h** and **bp.c**.