6]:	<pre>options(warn=-1) storeData <- read.csv('simmons.csv') Inspect the data read head(storeData)</pre>
~	Customer HasCard Spends UsesCoupon 1 0 8.5815985 1 2 0 1.4640473 0
	3 0 3.4647250 0 4 1 0.8019791 1 5 0 9.9601634 1 6 1 7.9306165 1
7]:	Spends are already reduced in given data. cat("Size of Store data", dim.data.frame(storeData)) Size of Store data 1000 4
	Question 1 - Fit a logistic regression model with the UsesCoupon as the response and other variables Spends and HasCard as potential predictors using gradient descent. Form the data matrix
18	<pre>colnames(y) <- c("UsesCoupon") ones <- matrix(rep(1,nrow(y)), nrow = nrow(y), ncol = 1) # data matrix A <- cbind(ones, storeData\$HasCard, storeData\$Spends) colnames(A) <- c("Ones", "HasCard", "Spends")</pre>
	head (y) head (A) UsesCoupon 1
	0 0 1
	Ones HasCard Spends 1 0 8.5815985 1 0 1.4640473
	1 0 3.4647250 1 1 0.8019791 1 0 9.9601634 1 1 7.9306165
	Modelling the success probability as $\hat{y}=\sigma(Ax)$ where $\sigma(z)=rac{e^z}{(1+e^z)}$
2]:	<pre># A is the data mtrix of dimension 1000 x 3 and x is the cofficeient matrix of dimension 3 x 1. # This function will return will return matric of dimension with 1000 x 1 with yi = sigmoid(Aixi) sigmoid <- function(x,A) { Ax <- A %*% x yhat <- apply(Ax,1, function (var) exp(var)/(1 + exp(var))) yhat <- as.matrix(yhat) colnames(yhat) <- c("Predicted_UsesCoupon")</pre>
61	return (yhat) } Calculating gradient
	<pre># This function will compute and return will gradient matrix with dim 3 x 1 gradient <- function(A,y,yhat){ N <- length(y) deltafx = matrix(rep(0,ncol(A)), nrow = ncol(A), ncol = 1) for(j in seq(nrow(deltafx))){ sum <- 0 for(i in seq(nrow(A))){</pre>
	<pre>temp <- (yhat[i] - y[i]) * A[i,j] sum <- sum + temp } deltafx[j] <- sum/N } rownames(deltafx) <- c("deltafx1", "deltafx2", "deltafx3") return (deltafx)</pre>
76	Defination of function for gradient descent
	<pre># This function do gradient descent and give optimimum cofficients gradientDescent <- function(y, A, x, alpha, thrs, maxi) { converged <-FALSE i <-1 x1 <-x while((!converged && i <= maxi)) {</pre>
	<pre>yhat <- sigmoid(x1,A) deltafx <- gradient(A,y,yhat) if(is.infinite(deltafx) is.nan(norm(deltafx,type = "2"))){ break } x1 <- x1 - (alpha*deltafx)</pre>
	<pre>converged <- (norm(deltafx,type = "2") <= thrs) i <- i+1 } return (list("x1"= x1,"iteration" = i-1,"converged" = converged)) }</pre>
77	<pre>#running gradient descent on data with different learning rate alphas <- c(10,5.0,1,0.5,0.1,0.01) thres <- 10**(-2) maxiter <- 10000 successalphs <- c() iternations <- list() xsfull <- list()</pre>
	<pre>x = matrix(rep(0,ncol(A)), nrow = ncol(A), ncol = 1) rownames(x) <- c("x1", "x2", "x3") row = 1 for (alpha in alphas) { answer <- gradientDescent(y,A,x,alpha,thres,maxiter) if (answer\$converged) {</pre>
	<pre>successalphs <- append(successalphs,alpha) xsfull[[row]] <- answer\$x iternations[[row]] <- answer\$iteration row = row+1 } successalphs <- format(successalphs, scientific = FALSE)</pre>
	<pre>xsfull <- do.call(cbind, xsfull) iternations <- do.call(cbind, iternations) colnames(xsfull) <- successalphs colnames(iternations) <- successalphs modifiedxs <- format(xsfull, scientific = FALSE) modifiedxs</pre>
	iternations successalphs 10.0 5.0 1.0 0.5 0.1 x1 -15.367439 -8.479330 -4.929665 -4.925239 -4.920445
	x2 17.255413 10.574735 6.568382 6.562942 6.557031 x3 3.758761 2.140135 1.284105 1.283100 1.282012 10.0 5.0 1.0 0.5 0.1 105 150 339 679 3394
	1. '10.0' 2. ' 5.0' 3. ' 1.0' 4. ' 0.5'
78	<pre>5.'0.1' barplot(iternations, main="Interation vs alpha", names.arg = successalphs,</pre>
	Interation vs alpha
	3390 - 3051 -
	2712 - 2373 -
	2034 — 20
	1356 —
	1017 - 678 -
	339 -
	10.0 5.0 1.0 0.5 0.1 Alpha
79	<pre># selecting cofficients for learning rate 0.5 optimumx <- as.matrix(xsfull[,3]) optimumx x1 -4.929665</pre>
	x2 6.568382 x3 1.284105 Question 2 - Predict the probiblities of using coupons for given data
80	<pre># diving spending by 1000 to get smaller values annualSpendingR <- annualSpending/1000 ones <- rep(1,length(annualSpendingR)) HasCardYes <- rep(1,length(annualSpendingR))</pre>
81	<pre>HasCardNo <- rep(0,length(annualSpendingR)) dataMatrixYes <- cbind(ones, HasCardYes, annualSpendingR) dataMatrixNo <- cbind(ones, HasCardNo, annualSpendingR) yhatYes <- sigmoid(x = optimumx, A = dataMatrixYes) yhatNo <- sigmoid(x = optimumx, A = dataMatrixNo)</pre>
82 83	<pre>PredictionTable <- cbind(annualSpending, yhatYes, yhatNo) colnames(PredictionTable) <- c("Annual Spending", "Credit Card Yes", "Credit Card No") PredictionTable</pre>
	Annual Spending Credit Card Yes Credit Card No 1000 0.9489631 0.02544255 2000 0.9853265 0.08615953 3000 0.9958933 0.25400773
	4000 0.9988595 0.55150524
	5000 0.9996839 0.81620721 6000 0.9999125 0.94130784 7000 0.9999758 0.98302794
	6000 0.9999125 0.94130784 7000 0.9999758 0.98302794
	Question 3 - Comment on a marketing strategy based on the table above for maximizing the number of customers using your store coupons. Using above table as reference, as CEO I can have two strategies 1. I can encourage the customers without store card and with annual spending less than \$6000 to enroll for store credit card. This on the basis of observation that the customers with store card use coupons with high probability irrespective of annual spending less than \$6000 to enroll for store credit card.
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	Question 3 - Comment on a marketing strategy based on the table above for maximizing the number of customers using your store coupons. Using above table as reference, as CEO I can have two strategies 1. I can encourage the customers without store card and with annual spending less than \$6000 to enroll for store credit card. This on the basis of observation that the customers with store card use coupons with high probability irrespective of annual spending. 2. I can encourage the customers to increase their annual spening in my stores. This on the basis of observation that the customers with annual spening more than \$6000 use coupons with high probability irrespective of store card. Question 4 - Implement Polyak's momentum method to solve the logistic regression problem. # A is the data mtrix of dimension 1000 x 3, y is the output matrix of dimension 1000 x 1,
	Question 3 - Comment on a marketing strategy based on the table above for maximizing the number of customers using your store coupons. Using above table as reference, as CEO I can have two strategies 1. I can encourage the customers without store card and with annual spending less than \$6000 to enroll for store credit card. This on the basis of observation that the customers with store card use coupons with high probability irrespective of annual spending in my stores. This on the basis of observation that the customers with annual spening in my stores. This on the basis of observation that the customers with annual spening more than \$6000 use coupons with high probability irrespective of store card. Question 4 - Implement Polyak's momentum method to solve the logistic regression problem. # A is the data mtrix of dimension 1000 x 3, y is the output matrix of dimension 1000 x 1, # a a pha is the learning rate, three is the threshold for gradient norm for stopping, mxi is maximum if # This function do gradient descent and give optiminum cofficients polyakMomentum <- function(y, A, x, alpha, beta, thrs, maxi) {
	Question 3 - Comment on a marketing strategy based on the table above for maximizing the number of customers using your store coupons. Using above table as reference, as CEO I can have two strategies 1. I can encourage the customers without store card and with annual spending less than \$6000 to enroll for store credit card. This on the basis of observation that the customers with store card use coupons with high probability irrespective of annual spending in my stores. This on the basis of observation that the customers with annual spening in my stores. This on the basis of observation that the customers with annual spening more than \$6000 use coupons with high probability irrespective of store card. Question 4 - Implement Polyak's momentum method to solve the logistic regression problem. # A is the data mtrix of dimension 1000 x 3, y is the output matrix of dimension 1000 x 1, # alpha is the learning rate, thres is the threshold for gradient norm for stopping, mxi is maximum if # This function do gradient descent and give optiminum cofficients polyaktomentum <- function(y, A, x, alpha, beta, thrs, maxi) {
97	Question 3 - Comment on a marketing strategy based on the table above for maximizing the number of customers using your store coupons. Using above table as reference, as CEO I can have two strategies 1. I can encourage the customers without store card and with annual spending less than \$6000 to enroll for store credit card. This on the basis of observation that the customers with store card use coupons with high probability irrespective of annual spending. 2. I can encourage the customers to increase their annual spending more than \$6000 use coupons with high probability irrespective of store card. This on the basis of observation that the customers with annual spending more than \$6000 use coupons with high probability irrespective of store card. Question 4 - Implement Polyak's momentum method to solve the logistic regression problem. ### A is the data mtrix of dimension 1000 x 3, y is the output matrix of dimension 1000 x 1, # alpha is the learning rate, three is the threshold for gradient norm for stopping, mxi is maximum if this function do gradient descend and give optissions coefficients polyskomentum - function (y, A, x, alpha, beta, thra, maxi) { converged - FALSE
	Question 3 - Comment on a marketing strategy based on the table above for maximizing the number of customers using your store coupons. Using above table as reference, as CEO I can have two strategies 1. I can encourage the customers without store card and with annual spending less than \$6000 to enroll for store credit card. This on the basis of observation that the customers with store card use coupons with high probability irrespective of annual spending. 2. I can encourage the customers to increase their annual spending more than \$6000 use coupons with high probability irrespective of store card. This on the basis of observation that the customers with annual spending more than \$6000 use coupons with high probability irrespective of store card. Question 4 - Implement Polyak's momentum method to solve the logistic regression problem. ### A is the data mtrix of dimension 1000 x 3, y is the output matrix of dimension 1000 x 1, # alpha is the learning rate, three is the threshold for gradient norm for stopping, mxi is maximum if this function do gradient descend and give optissions coefficients polyskomentum - function (y, A, x, alpha, beta, thra, maxi) { converged - FALSE
97	Question 3 - Comment on a marketing strategy based on the table above for maximizing the number of customers using your store coupons. Using above table as reference, as CEO I can have two strategies 1. I can encourage the customers without store card and with annual spending less than \$6000 to enroll for store credit card. This on the basis of observation that the customers with store card use coupons with high probability irrespective of annual spending in my stores. This on the basis of observation that the customers with annual spending in my stores. This on the basis of observation that the customers with annual spending more than \$6000 use coupons with high probability irrespective of store card. Question 4 - Implement Polyak's momentum method to solve the logistic regression problem. **A is the data matrix of dimension 1000 x 3, y is the output matrix of dimension 1000 x 1, \$ explain is the forering race, chrow is the threshold for gradient norm for stopping, exi to maximum (if \$ 1 trunclion do gradient dement, and give optimizem coefficients polyal/domentum of function (y, A, x, alpha, beta, thra, maxi) { converged c-PALSE
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