

Introduction of R in using optim() and Newton's Method

Linxi Li T00622714

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R Markdown

This is a tutorial on how to use optim() and Newton's Method to compute the maximum likelihood estimation of logistic regression.

At the beginning, you need to have your logit data. In my project, I simulated the data as:

```
# Simulated data
x <- c(0.50,0.75,1.00,1.25,1.50,1.75,1.75,2.00,2.25,2.50,2.75,3.00,3.25,3.50,4.00,
       4.25,4.50,4.75,5.00,5.50)
y <- c(0,0,0,0,0,0,1,0,1,0,1,0,1,0,1,1,1,1,1,1)
```

Or you can also upload your data.csv by using read.csv("/your local location/filename.csv"), for example:

```
data <- read.csv("/Users/ccc/Desktop/data.csv")
data
```

```
##      X y
## 1  0.50 0
## 2  0.75 0
## 3  1.00 0
## 4  1.25 0
## 5  1.50 0
## 6  1.75 0
## 7  1.75 1
## 8  2.00 0
## 9  2.25 1
## 10 2.50 0
## 11 2.75 1
## 12 3.00 0
## 13 3.25 1
## 14 3.50 0
## 15 4.00 1
## 16 4.25 1
## 17 4.50 1
## 18 4.75 1
## 19 5.00 1
## 20 5.50 1
```

and then you can assign your x and y from the data file you upload, such that:

```
x1 <- data$X
y1 <- data$y
```

In my project, at the really beginning, I used the `glm()` to estimate the MLE of my data by using the family of “binomial”. Usually, `glm()` will give us a more realistic answer. Therefore, we can find out the different by comparing the answers given by `optim()`, Newton’s method to the `glm()`.

```
#glm
mylogit <- glm(y ~ x, family = "binomial"(link = "logit"))
mylogit

##
## Call:  glm(formula = y ~ x, family = binomial(link = "logit"))
##
## Coefficients:
## (Intercept)          x
##      -4.078        1.505
##
## Degrees of Freedom: 19 Total (i.e. Null);  18 Residual
## Null Deviance:      27.73
## Residual Deviance: 16.06    AIC: 20.06
```

As we know that, `b0` is intercept, and `b1` represents the slope, so we can get our result from `glm()` that `b0` is -4.078, and `b1` is 1.505.

After getting the result from `glm()`, we can start using `optim()` to get MLE.

`optim()`

```
#MLE for logistic

nlogL_logstic <- function(paravec){
  # paravec[1] - b0
  # paravec[2] - b1
  sum(y*paravec[1])+sum(y*paravec[2]*x)-sum(log(1+exp(paravec[1]+paravec[2]*x)))
}

MLE = optim(c(0,0), #because we have two parameters in the function;
           fn=nlogL_logstic,
           method = "L-BFGS-B",
           control = list(fnscale = -1),
           hessian = FALSE)

MLE

## $par
## [1] -4.077802  1.504685
##
## $value
## [1] -8.029878
```

```
##
## $counts
## function gradient
##      14      14
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```

The `optim()` gives the result of `b0` is -4.0778, and `b1` is 1.504685, which are very much close to the `glm()` result.

Finally, we use Newton's Method to compare by using the derivative of the log likelihood function and derivative of the score function.

```
#Newton of b0 and b1
nlogL_log <- function(b0,b1){
  # b0
  # b1
  sum(y*(b0+b1*x))-sum(log(1+exp(b0+b1*x)))
}

nor_MLE_of_Newtown <- function(x, itr, b00=0,b11=0) {
  # input: x-vector of observations; itr- iteration times; b00,b11 - initial value
  # output: MLE estimate and maximum log-likelihood value
  b0<- rep(0,itr+1)
  b1<- rep(0,itr+1)
  b0[1] <- b00
  b1[1] <- b11
  for (i in 1:itr){
    #b[n+1] = b[n] - l(bn)/l'(bn)
    b0[i+1] = b0[i] - (sum(y)-sum(exp(b0[i]+b1[i]*x)/(1+exp(b0[i]+b1[i]*x)))/
      (-sum((exp(b0[i]+b1[i]*x))/(exp(b0[i]+b1[i]*x)+1)^2)))

    #sigma2[i+1] = sigma[i] - sigma[i] + (1/n * sum((xi - mu)^2))
    b1[i+1]=b1[i] - (sum(x*y)-sum(x*exp(b0[i]+b1[i]*x)/(1+exp(b0[i]+b1[i]*x)))/
      (-sum((x^2)*exp(b0[i]+b1[i]*x))/(exp(b0[i]+b1[i]*x)^2)))

  }
  data.frame(b0=b0, b1=b1,log.lik.value=nlogL_log(b0,b1))
}

n<-x
nor_MLE_of_Newtown(n,1000) # iterate 1000 times
```

```
## Warning in b1 * x: longer object length is not a multiple of shorter object
## length
```

```
## Warning in y * (b0 + b1 * x): longer object length is not a multiple of shorter
## object length
```

```
## Warning in b1 * x: longer object length is not a multiple of shorter object
## length
```

##		b0	b1	log.lik.value
## 1		0.0000000	0.0000000	-405.7357
## 2		0.0000000	0.05099150	-405.7357
## 3		-0.1426080	0.09803319	-405.7357
## 4		-0.2735782	0.14502350	-405.7357
## 5		-0.4044333	0.19124361	-405.7357
## 6		-0.5330174	0.23654028	-405.7357
## 7		-0.6588953	0.28072242	-405.7357
## 8		-0.7815187	0.32364509	-405.7357
## 9		-0.9004769	0.36519716	-405.7357
## 10		-1.0154598	0.40530102	-405.7357
## 11		-1.1262560	0.44390887	-405.7357
## 12		-1.2327412	0.48099863	-405.7357
## 13		-1.3348658	0.51656974	-405.7357
## 14		-1.4326417	0.55063898	-405.7357
## 15		-1.5261305	0.58323671	-405.7357
## 16		-1.6154315	0.61440352	-405.7357
## 17		-1.7006722	0.64418738	-405.7357
## 18		-1.7820000	0.67264124	-405.7357
## 19		-1.8595753	0.69982118	-405.7357
## 20		-1.9335660	0.72578477	-405.7357
## 21		-2.0041429	0.75058998	-405.7357
## 22		-2.0714769	0.77429418	-405.7357
## 23		-2.1357361	0.79695353	-405.7357
## 24		-2.1970838	0.81862245	-405.7357
## 25		-2.2556780	0.83935333	-405.7357
## 26		-2.3116698	0.85919629	-405.7357
## 27		-2.3652031	0.87819903	-405.7357
## 28		-2.4164146	0.89640685	-405.7357
## 29		-2.4654335	0.91386258	-405.7357
## 30		-2.5123816	0.93060667	-405.7357
## 31		-2.5573736	0.94667723	-405.7357
## 32		-2.6005172	0.96211011	-405.7357
## 33		-2.6419136	0.97693904	-405.7357
## 34		-2.6816575	0.99119567	-405.7357
## 35		-2.7198378	1.00490975	-405.7357
## 36		-2.7565377	1.01810919	-405.7357
## 37		-2.7918353	1.03082020	-405.7357
## 38		-2.8258036	1.04306736	-405.7357
## 39		-2.8585110	1.05487376	-405.7357
## 40		-2.8900215	1.06626108	-405.7357
## 41		-2.9203954	1.07724968	-405.7357
## 42		-2.9496890	1.08785868	-405.7357
## 43		-2.9779551	1.09810608	-405.7357
## 44		-3.0052434	1.10800878	-405.7357
## 45		-3.0316004	1.11758270	-405.7357
## 46		-3.0570699	1.12684282	-405.7357
## 47		-3.0816931	1.13580326	-405.7357
## 48		-3.1055088	1.14447733	-405.7357
## 49		-3.1285534	1.15287756	-405.7357
## 50		-3.1508612	1.16101582	-405.7357

## 51	-3.1724646	1.16890328	-405.7357
## 52	-3.1933943	1.17655050	-405.7357
## 53	-3.2136789	1.18396749	-405.7357
## 54	-3.2333458	1.19116370	-405.7357
## 55	-3.2524207	1.19814808	-405.7357
## 56	-3.2709280	1.20492911	-405.7357
## 57	-3.2888907	1.21151484	-405.7357
## 58	-3.3063305	1.21791288	-405.7357
## 59	-3.3232684	1.22413048	-405.7357
## 60	-3.3397237	1.23017451	-405.7357
## 61	-3.3557153	1.23605150	-405.7357
## 62	-3.3712606	1.24176767	-405.7357
## 63	-3.3863766	1.24732892	-405.7357
## 64	-3.4010793	1.25274088	-405.7357
## 65	-3.4153837	1.25800892	-405.7357
## 66	-3.4293045	1.26313813	-405.7357
## 67	-3.4428552	1.26813339	-405.7357
## 68	-3.4560492	1.27299935	-405.7357
## 69	-3.4688989	1.27774044	-405.7357
## 70	-3.4814162	1.28236089	-405.7357
## 71	-3.4936125	1.28686477	-405.7357
## 72	-3.5054988	1.29125594	-405.7357
## 73	-3.5170854	1.29553811	-405.7357
## 74	-3.5283823	1.29971482	-405.7357
## 75	-3.5393989	1.30378945	-405.7357
## 76	-3.5501445	1.30776528	-405.7357
## 77	-3.5606277	1.31164541	-405.7357
## 78	-3.5708569	1.31543282	-405.7357
## 79	-3.5808401	1.31913040	-405.7357
## 80	-3.5905850	1.32274088	-405.7357
## 81	-3.6000989	1.32626692	-405.7357
## 82	-3.6093888	1.32971104	-405.7357
## 83	-3.6184617	1.33307569	-405.7357
## 84	-3.6273240	1.33636321	-405.7357
## 85	-3.6359819	1.33957586	-405.7357
## 86	-3.6444415	1.34271580	-405.7357
## 87	-3.6527086	1.34578512	-405.7357
## 88	-3.6607888	1.34878584	-405.7357
## 89	-3.6686874	1.35171989	-405.7357
## 90	-3.6764096	1.35458913	-405.7357
## 91	-3.6839603	1.35739536	-405.7357
## 92	-3.6913444	1.36014032	-405.7357
## 93	-3.6985664	1.36282568	-405.7357
## 94	-3.7056309	1.36545306	-405.7357
## 95	-3.7125421	1.36802401	-405.7357
## 96	-3.7193042	1.37054003	-405.7357
## 97	-3.7259212	1.37300258	-405.7357
## 98	-3.7323969	1.37541307	-405.7357
## 99	-3.7387351	1.37777285	-405.7357
## 100	-3.7449394	1.38008323	-405.7357
## 101	-3.7510132	1.38234548	-405.7357
## 102	-3.7569600	1.38456083	-405.7357
## 103	-3.7627830	1.38673046	-405.7357
## 104	-3.7684853	1.38885552	-405.7357

## 105	-3.7740701	1.39093713	-405.7357
## 106	-3.7795402	1.39297637	-405.7357
## 107	-3.7848985	1.39497427	-405.7357
## 108	-3.7901479	1.39693185	-405.7357
## 109	-3.7952908	1.39885009	-405.7357
## 110	-3.8003301	1.40072993	-405.7357
## 111	-3.8052681	1.40257231	-405.7357
## 112	-3.8101074	1.40437811	-405.7357
## 113	-3.8148503	1.40614820	-405.7357
## 114	-3.8194991	1.40788342	-405.7357
## 115	-3.8240560	1.40958459	-405.7357
## 116	-3.8285232	1.41125250	-405.7357
## 117	-3.8329027	1.41288792	-405.7357
## 118	-3.8371967	1.41449160	-405.7357
## 119	-3.8414071	1.41606426	-405.7357
## 120	-3.8455358	1.41760662	-405.7357
## 121	-3.8495848	1.41911934	-405.7357
## 122	-3.8535557	1.42060311	-405.7357
## 123	-3.8574504	1.42205857	-405.7357
## 124	-3.8612705	1.42348635	-405.7357
## 125	-3.8650179	1.42488707	-405.7357
## 126	-3.8686940	1.42626131	-405.7357
## 127	-3.8723004	1.42760967	-405.7357
## 128	-3.8758387	1.42893270	-405.7357
## 129	-3.8793104	1.43023095	-405.7357
## 130	-3.8827169	1.43150497	-405.7357
## 131	-3.8860597	1.43275526	-405.7357
## 132	-3.8893401	1.43398235	-405.7357
## 133	-3.8925594	1.43518672	-405.7357
## 134	-3.8957190	1.43636885	-405.7357
## 135	-3.8988201	1.43752922	-405.7357
## 136	-3.9018640	1.43866828	-405.7357
## 137	-3.9048519	1.43978647	-405.7357
## 138	-3.9077849	1.44088424	-405.7357
## 139	-3.9106643	1.44196200	-405.7357
## 140	-3.9134910	1.44302017	-405.7357
## 141	-3.9162663	1.44405916	-405.7357
## 142	-3.9189911	1.44507934	-405.7357
## 143	-3.9216666	1.44608112	-405.7357
## 144	-3.9242936	1.44706486	-405.7357
## 145	-3.9268733	1.44803092	-405.7357
## 146	-3.9294065	1.44897967	-405.7357
## 147	-3.9318943	1.44991145	-405.7357
## 148	-3.9343374	1.45082660	-405.7357
## 149	-3.9367369	1.45172545	-405.7357
## 150	-3.9390936	1.45260833	-405.7357
## 151	-3.9414083	1.45347555	-405.7357
## 152	-3.9436819	1.45432743	-405.7357
## 153	-3.9459152	1.45516425	-405.7357
## 154	-3.9481090	1.45598633	-405.7357
## 155	-3.9502640	1.45679394	-405.7357
## 156	-3.9523811	1.45758736	-405.7357
## 157	-3.9544609	1.45836688	-405.7357
## 158	-3.9565042	1.45913276	-405.7357

## 159	-3.9585118	1.45988527	-405.7357
## 160	-3.9604841	1.46062465	-405.7357
## 161	-3.9624221	1.46135117	-405.7357
## 162	-3.9643263	1.46206506	-405.7357
## 163	-3.9661973	1.46276657	-405.7357
## 164	-3.9680359	1.46345594	-405.7357
## 165	-3.9698426	1.46413339	-405.7357
## 166	-3.9716180	1.46479914	-405.7357
## 167	-3.9733627	1.46545343	-405.7357
## 168	-3.9750773	1.46609645	-405.7357
## 169	-3.9767623	1.46672843	-405.7357
## 170	-3.9784184	1.46734957	-405.7357
## 171	-3.9800461	1.46796007	-405.7357
## 172	-3.9816458	1.46856012	-405.7357
## 173	-3.9832181	1.46914993	-405.7357
## 174	-3.9847636	1.46972968	-405.7357
## 175	-3.9862827	1.47029956	-405.7357
## 176	-3.9877758	1.47085975	-405.7357
## 177	-3.9892436	1.47141042	-405.7357
## 178	-3.9906863	1.47195175	-405.7357
## 179	-3.9921046	1.47248391	-405.7357
## 180	-3.9934988	1.47300706	-405.7357
## 181	-3.9948695	1.47352138	-405.7357
## 182	-3.9962169	1.47402701	-405.7357
## 183	-3.9975416	1.47452413	-405.7357
## 184	-3.9988439	1.47501287	-405.7357
## 185	-4.0001243	1.47549340	-405.7357
## 186	-4.0013831	1.47596585	-405.7357
## 187	-4.0026207	1.47643038	-405.7357
## 188	-4.0038376	1.47688712	-405.7357
## 189	-4.0050341	1.47733622	-405.7357
## 190	-4.0062105	1.47777780	-405.7357
## 191	-4.0073672	1.47821202	-405.7357
## 192	-4.0085046	1.47863898	-405.7357
## 193	-4.0096230	1.47905883	-405.7357
## 194	-4.0107227	1.47947169	-405.7357
## 195	-4.0118041	1.47987767	-405.7357
## 196	-4.0128675	1.48027692	-405.7357
## 197	-4.0139132	1.48066953	-405.7357
## 198	-4.0149415	1.48105563	-405.7357
## 199	-4.0159528	1.48143533	-405.7357
## 200	-4.0169473	1.48180875	-405.7357
## 201	-4.0179253	1.48217599	-405.7357
## 202	-4.0188871	1.48253716	-405.7357
## 203	-4.0198330	1.48289236	-405.7357
## 204	-4.0207633	1.48324171	-405.7357
## 205	-4.0216783	1.48358530	-405.7357
## 206	-4.0225781	1.48392323	-405.7357
## 207	-4.0234631	1.48425560	-405.7357
## 208	-4.0243335	1.48458250	-405.7357
## 209	-4.0251896	1.48490403	-405.7357
## 210	-4.0260317	1.48522028	-405.7357
## 211	-4.0268599	1.48553135	-405.7357
## 212	-4.0276745	1.48583732	-405.7357

## 213	-4.0284757	1.48613827	-405.7357
## 214	-4.0292639	1.48643430	-405.7357
## 215	-4.0300391	1.48672549	-405.7357
## 216	-4.0308016	1.48701192	-405.7357
## 217	-4.0315516	1.48729367	-405.7357
## 218	-4.0322894	1.48757082	-405.7357
## 219	-4.0330152	1.48784345	-405.7357
## 220	-4.0337291	1.48811164	-405.7357
## 221	-4.0344313	1.48837546	-405.7357
## 222	-4.0351222	1.48863499	-405.7357
## 223	-4.0358017	1.48889029	-405.7357
## 224	-4.0364702	1.48914145	-405.7357
## 225	-4.0371279	1.48938852	-405.7357
## 226	-4.0377748	1.48963158	-405.7357
## 227	-4.0384112	1.48987070	-405.7357
## 228	-4.0390373	1.49010594	-405.7357
## 229	-4.0396533	1.49033737	-405.7357
## 230	-4.0402592	1.49056504	-405.7357
## 231	-4.0408554	1.49078903	-405.7357
## 232	-4.0414418	1.49100940	-405.7357
## 233	-4.0420188	1.49122620	-405.7357
## 234	-4.0425865	1.49143950	-405.7357
## 235	-4.0431449	1.49164936	-405.7357
## 236	-4.0436944	1.49185582	-405.7357
## 237	-4.0442349	1.49205895	-405.7357
## 238	-4.0447668	1.49225881	-405.7357
## 239	-4.0452900	1.49245544	-405.7357
## 240	-4.0458049	1.49264891	-405.7357
## 241	-4.0463114	1.49283926	-405.7357
## 242	-4.0468097	1.49302654	-405.7357
## 243	-4.0473001	1.49321081	-405.7357
## 244	-4.0477825	1.49339212	-405.7357
## 245	-4.0482572	1.49357051	-405.7357
## 246	-4.0487242	1.49374604	-405.7357
## 247	-4.0491837	1.49391874	-405.7357
## 248	-4.0496359	1.49408868	-405.7357
## 249	-4.0500808	1.49425588	-405.7357
## 250	-4.0505185	1.49442040	-405.7357
## 251	-4.0509492	1.49458229	-405.7357
## 252	-4.0513730	1.49474158	-405.7357
## 253	-4.0517900	1.49489831	-405.7357
## 254	-4.0522004	1.49505254	-405.7357
## 255	-4.0526041	1.49520430	-405.7357
## 256	-4.0530014	1.49535363	-405.7357
## 257	-4.0533923	1.49550057	-405.7357
## 258	-4.0537770	1.49564515	-405.7357
## 259	-4.0541555	1.49578743	-405.7357
## 260	-4.0545280	1.49592744	-405.7357
## 261	-4.0548945	1.49606520	-405.7357
## 262	-4.0552551	1.49620077	-405.7357
## 263	-4.0556100	1.49633417	-405.7357
## 264	-4.0559592	1.49646544	-405.7357
## 265	-4.0563029	1.49659462	-405.7357
## 266	-4.0566410	1.49672174	-405.7357

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## 949	-4.0777130	1.50464526	-405.7357
## 950	-4.0777130	1.50464526	-405.7357
## 951	-4.0777130	1.50464527	-405.7357
## 952	-4.0777130	1.50464527	-405.7357
## 953	-4.0777130	1.50464527	-405.7357
## 954	-4.0777130	1.50464527	-405.7357
## 955	-4.0777130	1.50464528	-405.7357
## 956	-4.0777130	1.50464528	-405.7357
## 957	-4.0777130	1.50464528	-405.7357
## 958	-4.0777130	1.50464528	-405.7357
## 959	-4.0777131	1.50464529	-405.7357
## 960	-4.0777131	1.50464529	-405.7357
## 961	-4.0777131	1.50464529	-405.7357
## 962	-4.0777131	1.50464529	-405.7357
## 963	-4.0777131	1.50464529	-405.7357
## 964	-4.0777131	1.50464530	-405.7357
## 965	-4.0777131	1.50464530	-405.7357
## 966	-4.0777131	1.50464530	-405.7357
## 967	-4.0777131	1.50464530	-405.7357
## 968	-4.0777131	1.50464531	-405.7357

```

## 969 -4.0777131 1.50464531 -405.7357
## 970 -4.0777131 1.50464531 -405.7357
## 971 -4.0777131 1.50464531 -405.7357
## 972 -4.0777131 1.50464531 -405.7357
## 973 -4.0777131 1.50464531 -405.7357
## 974 -4.0777131 1.50464532 -405.7357
## 975 -4.0777131 1.50464532 -405.7357
## 976 -4.0777131 1.50464532 -405.7357
## 977 -4.0777131 1.50464532 -405.7357
## 978 -4.0777132 1.50464532 -405.7357
## 979 -4.0777132 1.50464532 -405.7357
## 980 -4.0777132 1.50464533 -405.7357
## 981 -4.0777132 1.50464533 -405.7357
## 982 -4.0777132 1.50464533 -405.7357
## 983 -4.0777132 1.50464533 -405.7357
## 984 -4.0777132 1.50464533 -405.7357
## 985 -4.0777132 1.50464533 -405.7357
## 986 -4.0777132 1.50464534 -405.7357
## 987 -4.0777132 1.50464534 -405.7357
## 988 -4.0777132 1.50464534 -405.7357
## 989 -4.0777132 1.50464534 -405.7357
## 990 -4.0777132 1.50464534 -405.7357
## 991 -4.0777132 1.50464534 -405.7357
## 992 -4.0777132 1.50464534 -405.7357
## 993 -4.0777132 1.50464535 -405.7357
## 994 -4.0777132 1.50464535 -405.7357
## 995 -4.0777132 1.50464535 -405.7357
## 996 -4.0777132 1.50464535 -405.7357
## 997 -4.0777132 1.50464535 -405.7357
## 998 -4.0777132 1.50464535 -405.7357
## 999 -4.0777132 1.50464535 -405.7357
## 1000 -4.0777132 1.50464535 -405.7357
## 1001 -4.0777132 1.50464536 -405.7357

```

After iterating 1000 times, we can see our result of b0 is -4.077132, and b1 is 1.50464534, which are also close to glm() result.