**Supplementary materials:**

**M6A-GSMS: Computational Identification of N6-methyladenosine Sites with GBDT and Stacking Learning in Multiple Species**

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Table 1. The accuracy of  value in NMBAC algorithm.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameter λ | A.thaliana | D.melanogaster | Human | M.musculus | S.cerevisiae |
| λ=1 | 0.82820 | 0.51333 | 0.50510 | 0.60621 | 0.58870 |
| λ=2 | 0.82524 | 0.48333 | 0.49882 | 0.61586 | 0.57344 |
| λ=3 | 0.83165 | 0.49833 | 0.49853 | 0.60690 | 0.59560 |
| λ=4 | 0.83065 | 0.51500 | 0.49667 | 0.61517 | 0.58796 |
| λ=5 | 0.83041 | 0.48167 | 0.48912 | 0.59103 | 0.57382 |
| λ=6 | 0.83362 | 0.52333 | 0.49696 | 0.62690 | 0.57419 |
| λ=7 | 0.82327 | 0.53667 | 0.50324 | 0.62414 | 0.58795 |
| λ=8 | 0.82893 | 0.47667 | 0.49412 | 0.62966 | 0.56885 |
| λ=9 | 0.83091 | 0.49167 | 0.49569 | 0.63310 | 0.58261 |
| λ=10 | 0.82278 | 0.47833 | 0.49961 | 0.63793 | 0.49961 |

Table 2. The accuracy of λ value in PC-PseDNC-General algorithm.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameter λ | A.thaliana | D.melanogaster | Human | M.musculus | S.cerevisiae |
| λ=1 | 0.85713 | 0.47708 | 0.49779 | 0.64814 | 0.64052 |
| λ=2 | 0.85339 | 0.48958 | 0.49396 | 0.64660 | 0.63642 |
| λ=3 | 0.85330 | 0.49542 | 0.49932 | 0.64690 | 0.63880 |
| λ=4 | 0.85377 | 0.50475 | 0.49444 | 0.64872 | 0.64353 |
| λ=5 | 0.85472 | 0.47433 | 0.50117 | 0.64573 | 0.64663 |
| λ=6 | 0.85622 | 0.49800 | 0.49678 | 0.64555 | 0.64478 |
| λ=7 | 0.85380 | 0.51825 | 0.49771 | 0.65338 | 0.64492 |
| λ=8 | 0.85630 | 0.50017 | 0.49961 | 0.65419 | 0.64524 |
| λ=9 | 0.85830 | 0.51833 | 0.49679 | 0.64769 | 0.64237 |
| λ=10 | 0.85800 | 0.51675 | 0.49813 | 0.66200 | 0.64060 |

Table 3. The accuracy of  value in PC-PseDNC-General algorithm.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameter λ | A.thaliana | D.melanogaster | Human | M.musculus | S.cerevisiae |
|  | 0.85834 | 0.51425 | 0.50324 | 0.70034 | 0.63815 |
|  | 0.85553 | 0.50217 | 0.50698 | 0.64724 | 0.67658 |
|  | 0.85333 | 0.48225 | 0.48902 | 0.62121 | 0.64971 |
|  | 0.85030 | 0.48217 | 0.49772 | 0.62552 | 0.65076 |
|  | 0.84819 | 0.49800 | 0.50024 | 0.62879 | 0.67734 |
|  | 0.84013 | 0.50375 | 0.48400 | 0.68379 | 0.63642 |
|  | 0.83217 | 0.50408 | 0.49691 | 0.59190 | 0.67514 |
|  | 0.83361 | 0.49017 | 0.49738 | 0.63224 | 0.62122 |
|  | 0.82860 | 0.48958 | 0.50588 | 0.63172 | 0.64694 |
|  | 0.82837 | 0.49367 | 0.49968 | 0.57086 | 0.66157 |

Table 4. The accuracy of  value in PseDPC algorithm.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameter λ | A.thaliana | D.melanogaster | Human | M.musculus | S.cerevisiae |
|  | 0.8324 | 0.5533 | 0.4977 | 0.6505 | 0.5941 |
|  | 0.8378 | 0.5533 | 0.4970 | 0.6200 | 0.6205 |
|  | 0.8339 | 0.5683 | 0.4931 | 0.6169 | 0.6033 |
|  | 0.8363 | 0.5433 | 0.4982 | 0.6176 | 0.6151 |
|  | 0.8243 | 0.5583 | 0.4914 | 0.5978 | 0.6086 |
|  | 0.8260 | 0.5500 | 0.4999 | 0.5566 | 0.6144 |
|  | 0.8314 | 0.5467 | 0.5007 | 0.6533 | 0.5960 |
|  | 0.8275 | 0.5317 | 0.5035 | 0.6183 | 0.6117 |
|  | 0.8289 | 0.5250 | 0.5075 | 0.5914 | 0.6182 |
|  | 0.8321 | 0.5500 | 0.5017 | 0.6281 | 0.6147 |

Table 5. The relationship between parameters λ and  in PseDPC algorithm.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| λ | n | Accuracy | | | | |
| A.thaliana | D.melanogaster | Human | M.musculus | S.cerevisiae |
| 1 | 1 | 0.83559 | 0.52500 | 0.49765 | 0.62828 | 0.61089 |
| 1 | 2 | 0.84668 | 0.57333 | 0.50461 | 0.64069 | 0.64993 |
| 1 | 3 | 0.83686 | 0.51333 | 0.50578 | 0.65034 | 0.63806 |
| 1 | 4 | 0.84496 | 0.53667 | 0.50363 | 0.63793 | 0.64075 |
| 1 | 5 | 0.84176 | 0.53333 | 0.49941 | 0.63448 | 0.63845 |
| 1 | 6 | 0.84077 | 0.53333 | 0.49686 | 0.64828 | 0.64571 |
| 1 | 7 | 0.84397 | 0.51667 | 0.50039 | 0.63724 | 0.63426 |
| 2 | 1 | 0.84052 | 0.50000 | 0.48843 | 0.62345 | 0.62659 |
| 2 | 2 | 0.84150 | 0.54000 | 0.50725 | 0.63517 | 0.63615 |
| 2 | 3 | 0.83830 | 0.55667 | 0.49549 | 0.64552 | 0.63884 |
| 2 | 4 | 0.84126 | 0.53833 | 0.49824 | 0.63793 | 0.62890 |
| 2 | 5 | 0.84274 | 0.52833 | 0.49971 | 0.64276 | 0.63844 |
| 2 | 6 | 0.83633 | 0.53000 | 0.49480 | 0.64138 | 0.62658 |
| 2 | 7 | 0.84102 | 0.52333 | 0.49520 | 0.65517 | 0.62965 |
| 3 | 1 | 0.84052 | 0.50500 | 0.49922 | 0.61655 | 0.62621 |
| 3 | 2 | 0.83978 | 0.55500 | 0.49735 | 0.62966 | 0.63041 |
| 3 | 3 | 0.83781 | 0.52667 | 0.49118 | 0.64828 | 0.62619 |
| 3 | 4 | 0.84126 | 0.52000 | 0.49049 | 0.64552 | 0.64801 |
| 3 | 5 | 0.84225 | 0.53167 | 0.49588 | 0.64621 | 0.63117 |
| 3 | 6 | 0.83584 | 0.53500 | 0.49647 | 0.64000 | 0.63960 |
| 3 | 7 | 0.84299 | 0.56167 | 0.49618 | 0.62759 | 0.63039 |
| 4 | 1 | 0.83609 | 0.49667 | 0.50020 | 0.61655 | 0.61395 |
| 4 | 2 | 0.84027 | 0.54167 | 0.50010 | 0.64552 | 0.63385 |
| 4 | 3 | 0.84175 | 0.55500 | 0.49490 | 0.66207 | 0.63157 |
| 4 | 4 | 0.84718 | 0.53833 | 0.49480 | 0.64414 | 0.64493 |
| 4 | 5 | 0.84052 | 0.49167 | 0.49735 | 0.64897 | 0.64302 |
| 4 | 6 | 0.83978 | 0.52833 | 0.50382 | 0.63034 | 0.63767 |
| 4 | 7 | 0.84496 | 0.54833 | 0.49020 | 0.63586 | 0.62160 |
| 5 | 1 | 0.83806 | 0.50000 | 0.50235 | 0.61448 | 0.62122 |
| 5 | 2 | 0.84372 | 0.53667 | 0.50500 | 0.63862 | 0.63079 |
| 5 | 3 | 0.84126 | 0.53667 | 0.48775 | 0.64483 | 0.63001 |
| 5 | 4 | 0.84446 | 0.55000 | 0.49402 | 0.63586 | 0.62087 |
| 5 | 5 | 0.84077 | 0.53833 | 0.50951 | 0.64414 | 0.62849 |
| 5 | 6 | 0.8415 | 0.55000 | 0.50157 | 0.63586 | 0.62351 |
| 5 | 7 | 0.84225 | 0.51667 | 0.48873 | 0.63448 | 0.62811 |
| 6 | 1 | 0.83338 | 0.53167 | 0.49716 | 0.61655 | 0.61666 |
| 6 | 2 | 0.83953 | 0.51167 | 0.50745 | 0.63517 | 0.62429 |
| 6 | 3 | 0.83954 | 0.52167 | 0.50127 | 0.65517 | 0.62809 |
| 6 | 4 | 0.84028 | 0.54667 | 0.50245 | 0.64414 | 0.63961 |
| 6 | 5 | 0.84077 | 0.52333 | 0.49647 | 0.62828 | 0.62658 |
| 6 | 6 | 0.84003 | 0.53500 | 0.50363 | 0.63034 | 0.63537 |
| 6 | 7 | 0.8388 | 0.54667 | 0.50245 | 0.63172 | 0.62505 |
| 7 | 1 | 0.83979 | 0.50333 | 0.49853 | 0.62966 | 0.61281 |
| 7 | 2 | 0.83633 | 0.52167 | 0.50363 | 0.63724 | 0.63079 |
| 7 | 3 | 0.84151 | 0.51667 | 0.50167 | 0.65034 | 0.62888 |
| 7 | 4 | 0.84422 | 0.53833 | 0.49912 | 0.64966 | 0.63500 |
| 7 | 5 | 0.84028 | 0.53333 | 0.49608 | 0.63586 | 0.63040 |
| 7 | 6 | 0.83929 | 0.50667 | 0.58618 | 0.63310 | 0.63423 |
| 7 | 7 | 0.83954 | 0.52333 | 0.49422 | 0.62414 | 0.63461 |
| 8 | 1 | 0.83289 | 0.49667 | 0.49833 | 0.61448 | 0.61894 |
| 8 | 2 | 0.83633 | 0.54167 | 0.49686 | 0.62483 | 0.63157 |
| 8 | 3 | 0.83855 | 0.52833 | 0.49853 | 0.64483 | 0.62926 |
| 8 | 4 | 0.84472 | 0.52000 | 0.49304 | 0.63586 | 0.63613 |
| 8 | 5 | 0.84496 | 0.49500 | 0.50431 | 0.64345 | 0.63079 |
| 8 | 6 | 0.83929 | 0.52667 | 0.50314 | 0.63310 | 0.63157 |
| 8 | 7 | 0.83609 | 0.53500 | 0.49088 | 0.63517 | 0.62696 |
| 9 | 1 | 0.83485 | 0.51333 | 0.49520 | 0.61655 | 0.61586 |
| 9 | 2 | 0.8383 | 0.53667 | 0.49471 | 0.63724 | 0.63002 |
| 9 | 3 | 0.84151 | 0.52667 | 0.50314 | 0.64345 | 0.63808 |
| 9 | 4 | 0.84644 | 0.53333 | 0.50363 | 0.61724 | 0.63271 |
| 9 | 5 | 0.84595 | 0.51667 | 0.49667 | 0.62552 | 0.62465 |
| 9 | 6 | 0.84052 | 0.52167 | 0.49176 | 0.64483 | 0.62160 |
| 9 | 7 | 0.83979 | 0.51667 | 0.50333 | 0.61586 | 0.62621 |
| 10 | 1 | 0.8351 | 0.51833 | 0.50069 | 0.62621 | 0.63041 |
| 10 | 2 | 0.84175 | 0.54167 | 0.49814 | 0.63379 | 0.62467 |
| 10 | 3 | 0.83978 | 0.54000 | 0.50137 | 0.63310 | 0.63882 |
| 10 | 4 | 0.84447 | 0.53500 | 0.49902 | 0.61517 | 0.64647 |
| 10 | 5 | 0.84151 | 0.50500 | 0.50137 | 0.62207 | 0.58832 |
| 10 | 6 | 0.83929 | 0.53500 | 0.49324 | 0.63862 | 0.63002 |
| 10 | 7 | 0.84201 | 0.56833 | 0.49304 | 0.61448 | 0.63307 |
| 11 | 1 | 0.83436 | 0.50333 | 0.50049 | 0.60759 | 0.62314 |
| 11 | 2 | 0.84077 | 0.53667 | 0.50127 | 0.62897 | 0.62430 |
| 11 | 3 | 0.83928 | 0.51667 | 0.49863 | 0.64414 | 0.63961 |
| 11 | 4 | 0.84101 | 0.55833 | 0.50039 | 0.62759 | 0.63193 |
| 11 | 5 | 0.842 | 0.51667 | 0.50039 | 0.63448 | 0.62928 |
| 11 | 6 | 0.83708 | 0.52667 | 0.49647 | 0.61517 | 0.62926 |
| 11 | 7 | 0.83658 | 0.56500 | 0.49539 | 0.62966 | 0.62811 |
| 12 | 1 | 0.8356 | 0.49333 | 0.51088 | 0.60552 | 0.62656 |
| 12 | 2 | 0.83978 | 0.56167 | 0.49706 | 0.64621 | 0.62735 |
| 12 | 3 | 0.84175 | 0.52167 | 0.51039 | 0.62828 | 0.62506 |
| 12 | 4 | 0.84422 | 0.54833 | 0.49461 | 0.62621 | 0.63920 |
| 12 | 5 | 0.84249 | 0.53667 | 0.49324 | 0.63241 | 0.62734 |
| 12 | 6 | 0.842 | 0.57167 | 0.50010 | 0.63310 | 0.61856 |
| 12 | 7 | 0.8388 | 0.53833 | 0.49284 | 0.62690 | 0.63423 |
| 13 | 1 | 0.83905 | 0.49333 | 0.49490 | 0.61931 | 0.61930 |
| 13 | 2 | 0.8388 | 0.54333 | 0.50951 | 0.64690 | 0.62927 |
| 13 | 3 | 0.83633 | 0.51500 | 0.49676 | 0.64069 | 0.62811 |
| 13 | 4 | 0.84422 | 0.53833 | 0.49941 | 0.62138 | 0.64198 |
| 13 | 5 | 0.84372 | 0.50833 | 0.49902 | 0.61586 | 0.63348 |
| 13 | 6 | 0.83904 | 0.51333 | 0.49588 | 0.62621 | 0.64226 |
| 13 | 7 | 0.83929 | 0.55000 | 0.49196 | 0.62552 | 0.63843 |
| 14 | 1 | 0.83091 | 0.49667 | 0.51167 | 0.59793 | 0.61548 |
| 14 | 2 | 0.83756 | 0.54667 | 0.50127 | 0.63448 | 0.63502 |
| 14 | 3 | 0.83929 | 0.50333 | 0.50118 | 0.64759 | 0.63577 |
| 14 | 4 | 0.84225 | 0.53667 | 0.49814 | 0.61655 | 0.64417 |
| 14 | 5 | 0.84126 | 0.50667 | 0.49755 | 0.63448 | 0.64151 |
| 14 | 6 | 0.84077 | 0.50500 | 0.49118 | 0.63379 | 0.62237 |
| 14 | 7 | 0.83683 | 0.52500 | 0.48510 | 0.61793 | 0.62273 |
| 15 | 1 | 0.83904 | 0.48000 | 0.50931 | 0.61586 | 0.61891 |
| 15 | 2 | 0.84052 | 0.53667 | 0.51118 | 0.63034 | 0.62353 |
| 15 | 3 | 0.83977 | 0.53000 | 0.48853 | 0.61172 | 0.63730 |
| 15 | 4 | 0.84397 | 0.55000 | 0.50324 | 0.62345 | 0.64073 |
| 15 | 5 | 0.84348 | 0.50667 | 0.49549 | 0.61724 | 0.62544 |
| 15 | 6 | 0.84002 | 0.49500 | 0.49637 | 0.62621 | 0.62010 |
| 15 | 7 | 0.84077 | 0.53000 | 0.49431 | 0.63034 | 0.62274 |
| 16 | 1 | 0.83782 | 0.47833 | 0.50765 | 0.61034 | 0.62198 |
| 16 | 2 | 0.84348 | 0.53333 | 0.51039 | 0.62828 | 0.62316 |
| 16 | 3 | 0.84249 | 0.50333 | 0.49275 | 0.62414 | 0.62735 |
| 16 | 4 | 0.84397 | 0.54333 | 0.50294 | 0.62897 | 0.64111 |
| 16 | 5 | 0.84298 | 0.56333 | 0.50784 | 0.63034 | 0.58185 |
| 16 | 6 | 0.84446 | 0.51167 | 0.49667 | 0.62966 | 0.63462 |
| 16 | 7 | 0.84224 | 0.53000 | 0.49520 | 0.62621 | 0.62353 |
| 17 | 1 | 0.83535 | 0.49667 | 0.49049 | 0.61397 | 0.61050 |
| 17 | 2 | 0.84372 | 0.54000 | 0.50088 | 0.63793 | 0.61855 |
| 17 | 3 | 0.84175 | 0.52667 | 0.49794 | 0.62552 | 0.63500 |
| 17 | 4 | 0.83953 | 0.53333 | 0.50333 | 0.63034 | 0.63232 |
| 17 | 5 | 0.84249 | 0.51000 | 0.49578 | 0.62690 | 0.63499 |
| 17 | 6 | 0.84225 | 0.53167 | 0.50000 | 0.64000 | 0.62582 |
| 17 | 7 | 0.83929 | 0.50667 | 0.49716 | 0.61862 | 0.61663 |
| 18 | 1 | 0.8351 | 0.49667 | 0.50265 | 0.61586 | 0.62276 |
| 18 | 2 | 0.84545 | 0.55000 | 0.50039 | 0.63241 | 0.63540 |
| 18 | 3 | 0.84323 | 0.57833 | 0.49412 | 0.63655 | 0.62658 |
| 18 | 4 | 0.83928 | 0.51667 | 0.50843 | 0.62966 | 0.64072 |
| 18 | 5 | 0.84742 | 0.53500 | 0.49912 | 0.62552 | 0.62160 |
| 18 | 6 | 0.84101 | 0.50167 | 0.50137 | 0.61655 | 0.62426 |
| 18 | 7 | 0.84102 | 0.53500 | 0.50304 | 0.62069 | 0.62391 |
| 19 | 1 | 0.83436 | 0.53500 | 0.49725 | 0.60069 | 0.61892 |
| 19 | 2 | 0.84175 | 0.53833 | 0.50353 | 0.62897 | 0.62391 |
| 19 | 3 | 0.84348 | 0.52667 | 0.49745 | 0.61862 | 0.62161 |
| 19 | 4 | 0.84471 | 0.49667 | 0.49598 | 0.63379 | 0.62429 |
| 19 | 5 | 0.84052 | 0.50333 | 0.49127 | 0.61724 | 0.59789 |
| 19 | 6 | 0.84545 | 0.50167 | 0.49461 | 0.62207 | 0.62238 |
| 19 | 7 | 0.83633 | 0.51333 | 0.49500 | 0.62759 | 0.62657 |
| 20 | 1 | 0.83658 | 0.48333 | 0.49422 | 0.61034 | 0.61624 |
| 20 | 2 | 0.84544 | 0.55500 | 0.50039 | 0.62759 | 0.62928 |
| 20 | 3 | 0.84323 | 0.53000 | 0.50598 | 0.63931 | 0.63001 |
| 20 | 4 | 0.84224 | 0.53667 | 0.49775 | 0.63448 | 0.63156 |
| 20 | 5 | 0.84496 | 0.52833 | 0.49755 | 0.62414 | 0.63193 |
| 20 | 6 | 0.84397 | 0.54667 | 0.49804 | 0.63724 | 0.62276 |
| 20 | 7 | 0.84003 | 0.52500 | 0.50451 | 0.62552 | 0.61971 |

Table 6. Optimal parameter selection of different models.

|  |  |  |
| --- | --- | --- |
| Species | Models | Parameters |
| A.thaliana | RF | n\_estimators=101, max\_depth=14, max\_features=16, min\_samples\_leaf=1, min\_samples\_split=2, criterion="gini" |
| ET | max\_depth=19, min\_samples\_split=10, criterion="entropy" |
| SVM | C=43172, gamma=2e-10 |
| LGBM | max\_depth=10, learning\_rate=0.12, feature\_fraction=0.3, lambda\_l1=0.6, lambda\_l2=26, cat\_smooth=15 |
| Bagging | n\_estimators=141 |
| Adaboost | learning\_rate=0.4, n\_estimators=98 |
| D.melanogaster | RF | n\_estimators=41, max\_depth=15, max\_features=15, min\_samples\_leaf=2, min\_samples\_split=4, criterion="gini" |
| ET | max\_depth=31, min\_samples\_split=18, criterion="entropy" |
| SVM | C=117603, gamma=2e-10 |
| LGBM | max\_depth=8, learning\_rate=0.02, feature\_fraction=0.3, lambda\_l1=0.3, lambda\_l2=23, cat\_smooth=30 |
| Bagging | n\_estimators=41 |
| Adaboost | learning\_rate=0.9, n\_estimators=80 |
| Human | RF | n\_estimators=171, max\_depth=17, max\_features=25, min\_samples\_leaf=5, min\_samples\_split=19, criterion="entropy" |
| ET | max\_depth=43, min\_samples\_split=15, criterion="entropy" |
| SVM | C=187353, gamma=2e-10 |
| LGBM | max\_depth=97, learning\_rate=0.05, feature\_fraction=0.9, lambda\_l1=0.1, lambda\_l2=19, cat\_smooth=21 |
| Bagging | n\_estimators=171 |
| Adaboost | learning\_rate=0.3, n\_estimators=50 |
| M.Musculus | RF | n\_estimators=171, max\_depth=1, max\_features=17, min\_samples\_leaf=19, min\_samples\_split=13, criterion="gini" |
| ET | max\_depth=3, min\_samples\_split=18, criterion="entropy" |
| SVM | C=151936, gamma=2e-10 |
| LGBM | max\_depth=8, learning\_rate=0.03, feature\_fraction=0.1, lambda\_l1=0.4, lambda\_l2=39, cat\_smooth=5 |
| Bagging | n\_estimators=171 |
| Adaboost | learning\_rate=0.2, n\_estimators=26 |
| S.cerevisiae | RF | n\_estimators=181, max\_depth=9, max\_features=22, min\_samples\_leaf=6, min\_samples\_split=19, criterion="entropy" |
| ET | max\_depth=41, min\_samples\_split=13, criterion="entropy" |
| SVM | C=112038, gamma=2e-10 |
| LGBM | max\_depth=46, learning\_rate=0.14, feature\_fraction=0.9, lambda\_l1=0.3, lambda\_l2=0, cat\_smooth=28 |
| Bagging | n\_estimators=141 |
| Adaboost | learning\_rate=0.3, n\_estimators=56 |