

4.1 Assembly do MIPS

Código em Assembly do MIPS.

```
InicializaJogador:                                # InicializaJogador - Início
    addiu $sp,$sp,-8
    sw    $fp,4($sp)
    move   $fp,$sp
    sw    $4,8($fp)
    sw    $5,12($fp)
    move   $2,$6
    sb    $2,16($fp)
    lw    $2,8($fp)
    lw    $3,12($fp)
    nop
    sw    $3,0($2)
    lw    $2,8($fp)
    li    $3,24                                # 0x18
    sw    $3,4($2)
    lw    $2,8($fp)
    li    $3,20                                # 0x14
    sw    $3,8($2)
    lw    $2,8($fp)
    lbu   $3,16($fp)
    nop
    sb    $3,12($2)
    nop
    move   $sp,$fp
    lw    $fp,4($sp)
    addiu $sp,$sp,8
    j     $31
    nop                                         # InicializaJogador - Fim
```

```
PosicionaJogador:                                # PosicionaJogador - Início
    addiu $sp,$sp,-24
    sw    $fp,20($sp)
    move   $fp,$sp
    sw    $4,24($fp)
    sw    $5,28($fp)
    sw    $6,32($fp)
    sw    $7,36($fp)
    lw    $2,28($fp)
    nop
    sw    $2,8($fp)
    b     $L3
    nop
```

```
$L4:
    lw    $2,24($fp)
    lb    $3,36($fp)
    lui   $4,%hi(Pong)
    lw    $5,8($fp)
    nop
    sll   $5,$5,6
    addiu $4,$4,%lo(Pong)
    addu   $4,$5,$4
    addu   $2,$4,$2
    sb    $3,0($2)
    lw    $2,8($fp)
    nop
    addiu $2,$2,1
    sw    $2,8($fp)
```

```
$L3:
    lw    $2,28($fp)
    nop
    addiu $3,$2,10
    lw    $2,8($fp)
```

```

nop
slt  $2,$3,$2
beq  $2,$0,$L4
nop

```

```

lw    $2,28($fp)
nop
sw    $2,8($fp)
b     $L5
nop

```

\$L6:

```

lw    $2,24($fp)
lb    $3,36($fp)
lui   $4,%hi(Pong)
lw    $5,8($fp)
nop
sll   $5,$5,6
addiu $4,$4,%lo(Pong)
addu  $4,$5,$4
addu  $2,$4,$2
sb    $3,0($2)
lw    $2,8($fp)
nop
addiu $2,$2,-1
sw    $2,8($fp)

```

\$L5:

```

lw    $2,28($fp)
nop
addiu $3,$2,-10
lw    $2,8($fp)
nop
slt   $2,$2,$3
beq   $2,$0,$L6
nop

```

```

nop
move  $sp,$fp
lw    $fp,20($sp)
addiu $sp,$sp,24
j     $31
nop

```

PosicionaJogador - Fim

EscolheMovimentoJogador:

EscolheMovimentoJogador - Início

```

addiu $sp,$sp,-8
sw    $fp,4($sp)
move  $fp,$sp
sw    $4,8($fp)
sw    $5,12($fp)
sw    $6,16($fp)
sw    $7,20($fp)
lw    $3,12($fp)
lw    $2,16($fp)
nop
srl   $4,$2,31
addu  $2,$4,$2
sra   $2,$2,1
subu  $2,$3,$2
addiu $2,$2,1
slt   $2,$2,3
beq   $2,$0,$L8
nop

```

```

lw    $2,24($fp)
nop
sw    $0,0($2)

```

\$L8:

```

lw    $3,12($fp)
lw    $2,16($fp)
nop
srl    $4,$2,31
addu   $2,$4,$2
sra    $2,$2,1
addu   $2,$3,$2
addiu  $2,$2,-1
slt    $2,$2,45
bne    $2,$0,$L9
nop

lw    $2,24($fp)
li     $3,1          # 0x1
sw    $3,0($2)

$L9:
nop
move   $sp,$fp
lw     $fp,4($sp)
addiu  $sp,$sp,8
j      $31
nop                                     # EscolheMovimentoJogador - Fim

MovimentaJogador:                    # MovimentaJogador - Início
addiu  $sp,$sp,-8
sw     $fp,4($sp)
move   $fp,$sp
sw     $4,8($fp)
sw     $5,12($fp)
lw     $3,12($fp)
li     $2,1          # 0x1
bne    $3,$2,$L11
nop

lw     $2,8($fp)
nop
lw     $2,4($2)
nop
addiu  $3,$2,-1
lw     $2,8($fp)
nop
sw     $3,4($2)
b      $L13
nop

$L11:
lw     $2,8($fp)
nop
lw     $2,4($2)
nop
addiu  $3,$2,1
lw     $2,8($fp)
nop
sw     $3,4($2)

$L13:
nop
move   $sp,$fp
lw     $fp,4($sp)
addiu  $sp,$sp,8
j      $31
nop                                     # MovimentaJogador - Fim

RandomizaInicioBola:                # RandomizaInicioBola - Início
addiu  $sp,$sp,-40
sw     $31,36($sp)
sw     $fp,32($sp)
sw     $16,28($sp)

```

```

    move $fp,$sp
    sw   $4,40($fp)
    move $4,$0
    jal  time
    nop

    move $4,$2
    jal  srand
    nop

    jal  rand
    nop

    move $3,$2
    li   $2,20          # 0x14
    bne  $2,$0,1f
    div  $0,$3,$2
    break 7

1:
    mfhi $2
    move $16,$2
    jal  rand
    nop

    move $3,$2
    li   $2,-2147483648 # 0xffffffff80000000
    ori  $2,$2,0x1
    and  $2,$3,$2
    bgez $2,$L15
    nop

    addiu $2,$2,-1
    li    $3,-2          # 0xfffffffffffffffe
    or    $2,$2,$3
    addiu $2,$2,1

$L15:
    mult $16,$2
    li   $2,24          # 0x18
    mflo $3
    subu $3,$2,$3
    lw   $2,40($fp)
    nop
    sw   $3,4($2)
    nop
    move $sp,$fp
    lw   $31,36($sp)
    lw   $fp,32($sp)
    lw   $16,28($sp)
    addiu $sp,$sp,40
    j    $31
    nop          # RandomizaInicioBola - Fim

InicializaBola:          # InicializaBola - Início
    addiu $sp,$sp,-32
    sw   $31,28($sp)
    sw   $fp,24($sp)
    move $fp,$sp
    sw   $4,32($fp)
    sw   $5,36($fp)
    move $2,$6
    sb   $2,40($fp)
    lw   $2,32($fp)
    lw   $3,36($fp)
    nop
    sw   $3,0($2)
    lw   $4,32($fp)
    jal  RandomizaInicioBola

```

```

nop

lw    $2,32($fp)
li    $3,1          # 0x1
sw    $3,8($2)
lw    $2,32($fp)
lbu   $3,40($fp)
nop
sb    $3,12($2)
nop
move  $sp,$fp
lw    $31,28($sp)
lw    $fp,24($sp)
addiu $sp,$sp,32
j     $31
nop                                     # InicializaBola - Fim

```

PosicionaBola: # PosicionaBola - Início

```

addiu $sp,$sp,-8
sw    $fp,4($sp)
move  $fp,$sp
sw    $4,8($fp)
lw    $2,8($fp)
nop
lw    $5,4($2)
lw    $2,8($fp)
nop
lw    $2,0($2)
lw    $3,8($fp)
nop
lb    $3,12($3)
lui   $4,%hi(Pong)
sll   $5,$5,6
addiu $4,$4,%lo(Pong)
addu  $4,$5,$4
addu  $2,$4,$2
sb    $3,0($2)
nop
move  $sp,$fp
lw    $fp,4($sp)
addiu $sp,$sp,8
j     $31
nop                                     # PosicionaBola - Fim

```

MovimentaBola: # MovimentaBola - Início

```

addiu $sp,$sp,-8
sw    $fp,4($sp)
move  $fp,$sp
sw    $4,8($fp)
sw    $5,12($fp)
sw    $6,16($fp)
lw    $2,8($fp)
nop
lw    $2,4($2)
nop
slt   $2,$2,2
beq   $2,$0,$L19
nop

lw    $2,16($fp)
nop
lw    $2,0($2)
nop
subu  $3,$0,$2
lw    $2,16($fp)
nop
sw    $3,0($2)

```

\$L19:

```
lw    $2,8($fp)
nop
lw    $2,4($2)
nop
slt   $2,$2,46
bne   $2,$0,$L20
nop
```

```
lw    $2,16($fp)
nop
lw    $2,0($2)
nop
subu   $3,$0,$2
lw    $2,16($fp)
nop
sw    $3,0($2)
```

\$L20:

```
lw    $2,8($fp)
nop
lw    $3,0($2)
lw    $2,12($fp)
nop
lw    $2,0($2)
nop
addu   $3,$3,$2
lw    $2,8($fp)
nop
sw    $3,0($2)
lw    $2,8($fp)
nop
lw    $3,4($2)
lw    $2,16($fp)
nop
lw    $2,0($2)
nop
addu   $3,$3,$2
lw    $2,8($fp)
nop
sw    $3,4($2)
nop
move   $sp,$fp
lw    $fp,4($sp)
addiu  $sp,$sp,8
j      $31
nop
```

MovimentaBola - Fim

Rebate:

```
addiu  $sp,$sp,-8
sw     $fp,4($sp)
move   $fp,$sp
sw     $4,8($fp)
sw     $5,12($fp)
sw     $6,16($fp)
lw     $2,12($fp)
nop
lw     $2,0($2)
nop
addiu  $3,$2,-1
lw     $2,8($fp)
nop
lw     $2,0($2)
nop
bne    $3,$2,$L22
nop
lw     $2,12($fp)
```

Rebate - Início

```

nop
lw    $3,4($2)
lw    $2,8($fp)
nop
lw    $4,4($2)
lw    $2,8($fp)
nop
lw    $2,8($2)
nop
srl    $5,$2,31
addu   $2,$5,$2
sra    $2,$2,1
addu   $2,$4,$2
slt    $2,$2,$3
bne    $2,$0,$L22
nop

lw    $2,12($fp)
nop
lw    $3,4($2)
lw    $2,8($fp)
nop
lw    $4,4($2)
lw    $2,8($fp)
nop
lw    $2,8($2)
nop
srl    $5,$2,31
addu   $2,$5,$2
sra    $2,$2,1
subu   $2,$4,$2
slt    $2,$3,$2
bne    $2,$0,$L22
nop

lw    $2,16($fp)
nop
lw    $2,0($2)
nop
subu   $3,$0,$2
lw    $2,16($fp)
nop
sw    $3,0($2)
$L22:
lw    $2,12($fp)
nop
lw    $2,0($2)
nop
addiu  $3,$2,1
lw    $2,8($fp)
nop
lw    $2,0($2)
nop
bne    $3,$2,$L24
nop

lw    $2,12($fp)
nop
lw    $3,4($2)
lw    $2,8($fp)
nop
lw    $4,4($2)
lw    $2,8($fp)
nop
lw    $2,8($2)
nop
srl    $5,$2,31

```

```

    addu    $2,$5,$2
    sra     $2,$2,1
    addu    $2,$4,$2
    slt     $2,$2,$3
    bne     $2,$0,$L24
    nop

    lw      $2,12($fp)
    nop
    lw      $3,4($2)
    lw      $2,8($fp)
    nop
    lw      $4,4($2)
    lw      $2,8($fp)
    nop
    lw      $2,8($2)
    nop
    srl     $5,$2,31
    addu    $2,$5,$2
    sra     $2,$2,1
    subu    $2,$4,$2
    slt     $2,$3,$2
    bne     $2,$0,$L24
    nop

    lw      $2,16($fp)
    nop
    lw      $2,0($2)
    nop
    subu    $3,$0,$2
    lw      $2,16($fp)
    nop
    sw      $3,0($2)
$L24:
    nop
    move    $sp,$fp
    lw      $fp,4($sp)
    addiu   $sp,$sp,8
    j       $31
    nop
# Rebate - Fim

VerificaPontuacao:
    addiu   $sp,$sp,-8
    sw      $fp,4($sp)
    move    $fp,$sp
    sw      $4,8($fp)
    sw      $5,12($fp)
    sw      $6,16($fp)
    sw      $7,20($fp)
    lw      $2,8($fp)
    nop
    slt     $2,$2,63
    bne     $2,$0,$L26
    nop

    lw      $2,24($fp)
    nop
    lw      $2,0($2)
    nop
    addiu   $3,$2,1
    lw      $2,24($fp)
    nop
    sw      $3,0($2)
    li      $2,1
    b       $L27
    nop
# 0x1

```



```

$L26:
    lw    $2,8($fp)
    nop
    bgtz  $2,$L28
    nop

    lw    $2,28($fp)
    nop
    lw    $2,0($2)
    nop
    addiu $3,$2,1
    lw    $2,28($fp)
    nop
    sw    $3,0($2)
    li    $2,1                # 0x1
    b     $L27
    nop

$L28:
    move  $2,$0

$L27:
    move  $sp,$fp
    lw    $fp,4($sp)
    addiu $sp,$sp,8
    j     $31                # VerificaPontuacao - Início
    nop

$LC0:
    .ascii " JOGADOR 1: %.2d\011\011x\011\011JOGADOR 2: %.2d\012\000"
ImprimePontuacao:                # ImprimePontuacao - Início
    addiu $sp,$sp,-32
    sw    $31,28($sp)
    sw    $fp,24($sp)
    move  $fp,$sp
    sw    $4,32($fp)
    sw    $5,36($fp)
    lw    $6,36($fp)
    lw    $5,32($fp)
    lui   $2,%hi($LC0)
    addiu $4,$2,%lo($LC0)
    jal   printf
    nop

    nop
    move  $sp,$fp
    lw    $31,28($sp)
    lw    $fp,24($sp)
    addiu $sp,$sp,32
    j     $31                # ImprimePontuacao - Fim
    nop

InicializaPong:                # InicializaPong - Início
    addiu $sp,$sp,-24
    sw    $fp,20($sp)
    move  $fp,$sp
    sw    $0,8($fp)
    b     $L31
    nop

$L32:
    lui   $2,%hi(Pong)
    lw    $3,8($fp)
    nop
    sll   $3,$3,6
    addiu $2,$2,%lo(Pong)
    addu  $2,$3,$2
    li    $3,124            # 0x7c

```

```

    sb    $3,0($2)
    lui   $2,%hi(Pong)
    lw    $3,8($fp)
    nop
    sll   $3,$3,6
    addiu $2,$2,%lo(Pong)
    addu  $2,$3,$2
    li    $3,124          # 0x7c
    sb    $3,63($2)
    lw    $2,8($fp)
    nop
    addiu $2,$2,1
    sw    $2,8($fp)
$L31:
    lw    $2,8($fp)
    nop
    slt   $2,$2,48
    bne   $2,$0,$L32
    nop

    sw    $0,8($fp)
    b     $L33
    nop

$L34:
    lui   $2,%hi(Pong)
    addiu $3,$2,%lo(Pong)
    lw    $2,8($fp)
    nop
    addu  $2,$3,$2
    li    $3,61           # 0x3d
    sb    $3,0($2)
    lui   $2,%hi(Pong)
    lw    $3,8($fp)
    addiu $2,$2,%lo(Pong)
    addu  $2,$3,$2
    li    $3,61           # 0x3d
    sb    $3,3008($2)
    lw    $2,8($fp)
    nop
    addiu $2,$2,1
    sw    $2,8($fp)
$L33:
    lw    $2,8($fp)
    nop
    slt   $2,$2,64
    bne   $2,$0,$L34
    nop

    li    $2,1           # 0x1
    sw    $2,8($fp)
    b     $L35
    nop

$L38:
    li    $2,1           # 0x1
    sw    $2,12($fp)
    b     $L36
    nop

$L37:
    lui   $2,%hi(Pong)
    lw    $3,8($fp)
    nop
    sll   $3,$3,6
    addiu $2,$2,%lo(Pong)
    addu  $3,$3,$2

```

```

        lw    $2,12($fp)
        nop
        addu  $2,$3,$2
        li    $3,32                # 0x20
        sb    $3,0($2)
        lw    $2,12($fp)
        nop
        addiu $2,$2,1
        sw    $2,12($fp)
$L36:
        lw    $2,12($fp)
        nop
        slt   $2,$2,63
        bne   $2,$0,$L37
        nop

        lw    $2,8($fp)
        nop
        addiu $2,$2,1
        sw    $2,8($fp)
$L35:
        lw    $2,8($fp)
        nop
        slt   $2,$2,47
        bne   $2,$0,$L38
        nop

        nop
        move  $sp,$fp
        lw    $fp,20($sp)
        addiu $sp,$sp,24
        j     $31
        nop                # InicializaPong - Fim

AtualizaPong:                # AtualizaPong - Início
        addiu $sp,$sp,-32
        sw    $31,28($sp)
        sw    $fp,24($sp)
        move  $fp,$sp
        sw    $4,32($fp)
        sw    $5,36($fp)
        sw    $6,40($fp)
        sw    $7,44($fp)
        jal   InicializaPong
        nop

        lw    $4,32($fp)
        lw    $5,36($fp)
        lw    $6,40($fp)
        lw    $7,44($fp)
        jal   PosicionaJogador
        nop

        lw    $4,48($fp)
        lw    $5,52($fp)
        lw    $6,56($fp)
        lw    $7,60($fp)
        jal   PosicionaJogador
        nop

        addiu $2,$fp,64
        move  $4,$2
        jal   PosicionaBola
        nop

        nop
        move  $sp,$fp

```

```

        lw    $31,28($sp)
        lw    $fp,24($sp)
        addiu $sp,$sp,32
        j     $31
        nop                                     # AtualizaPong - Fim

ImprimePong:                                # ImprimePong - Início
        addiu $sp,$sp,-40
        sw    $31,36($sp)
        sw    $fp,32($sp)
        move  $fp,$sp
        sw    $0,24($fp)
        b     $L41
        nop

$L44:
        sw    $0,28($fp)
        b     $L42
        nop

$L43:
        lui   $2,%hi(Pong)
        lw    $3,24($fp)
        nop
        sll   $3,$3,6
        addiu $2,$2,%lo(Pong)
        addu  $3,$3,$2
        lw    $2,28($fp)
        nop
        addu  $2,$3,$2
        lb    $2,0($2)
        nop
        move  $4,$2
        jal   putchar
        nop

        lw    $2,28($fp)
        nop
        addiu $2,$2,1
        sw    $2,28($fp)

$L42:
        lw    $2,28($fp)
        nop
        slt   $2,$2,64
        bne   $2,$0,$L43
        nop

        li    $4,10                          # 0xa
        jal   putchar
        nop

        lw    $2,24($fp)
        nop
        addiu $2,$2,1
        sw    $2,24($fp)

$L41:
        lw    $2,24($fp)
        nop
        slt   $2,$2,48
        bne   $2,$0,$L44
        nop

        nop
        move  $sp,$fp
        lw    $31,36($sp)
        lw    $fp,32($sp)
        addiu $sp,$sp,40

```

```

        j    $31
        nop                                     # ImprimePong - Fim

$LC1:
        .ascii "\011\011\011PONG NO TERMINAL\000"
$LC2:
        .ascii "\033c\000"
main:                                     # main - Inicio
        addiu $sp,$sp,-136
        sw    $31,132($sp)
        sw    $fp,128($sp)
        move  $fp,$sp
        sw    $0,108($fp)
        sw    $0,116($fp)
        li    $2,1                         # 0x1
        sw    $2,120($fp)
        li    $2,1                         # 0x1
        sw    $2,124($fp)
        li    $6,93                        # 0x5d
        li    $5,1                         # 0x1
        addiu $2,$fp,56
        move  $4,$2
        jal   InicializaJogador
        nop

        addiu $2,$fp,72
        li    $6,91                        # 0x5b
        li    $5,62                        # 0x3e
        move  $4,$2
        jal   InicializaJogador
        nop

        addiu $2,$fp,88
        li    $6,79                        # 0x4f
        li    $5,32                        # 0x20
        move  $4,$2
        jal   InicializaBola
        nop

        move  $4,$0
        jal   time
        nop

        move  $4,$2
        jal   srand
        nop

        jal   rand
        nop

        move  $3,$2
        li    $2,-2147483648                # 0xffffffff80000000
        ori   $2,$2,0x1
        and   $2,$3,$2
        bgez  $2,$L46
        nop

        addiu $2,$2,-1
        li    $3,-2                         # 0xfffffffffffffffe
        or    $2,$2,$3
        addiu $2,$2,1
$L46:
        sw    $2,104($fp)
        lw    $3,104($fp)
        li    $2,1                         # 0x1
        bne   $3,$2,$L47
        nop

```

```

sw    $0,112($fp)
b     $L48
nop

$L47:
li    $2,1                # 0x1
sw    $2,112($fp)
$L48:
lui   $2,%hi($LC1)
addiu $4,$2,%lo($LC1)
jal   puts
nop

lw    $5,88($fp)
lw    $4,92($fp)
lw    $3,96($fp)
lw    $2,100($fp)
sw    $5,32($sp)
sw    $4,36($sp)
sw    $3,40($sp)
sw    $2,44($sp)
lw    $5,72($fp)
lw    $4,76($fp)
lw    $3,80($fp)
lw    $2,84($fp)
sw    $5,16($sp)
sw    $4,20($sp)
sw    $3,24($sp)
sw    $2,28($sp)
lw    $4,56($fp)
lw    $5,60($fp)
lw    $6,64($fp)
lw    $7,68($fp)
jal   AtualizaPong        # Chamada da função AtualizaPong
nop

jal   ImprimePong         # Chamada da função ImprimePong
nop

lw    $2,108($fp)
lw    $3,116($fp)
nop
move  $5,$3
move  $4,$2
jal   ImprimePontuacao    # Chamada da função ImprimePong
nop

addiu $2,$fp,104
sw    $2,16($sp)
lw    $4,56($fp)
lw    $5,60($fp)
lw    $6,64($fp)
lw    $7,68($fp)
jal   EscolheMovimentoJogador # Chamada da função EscolheMovimentoJogador
nop

addiu $2,$fp,112
sw    $2,16($sp)
lw    $4,72($fp)
lw    $5,76($fp)
lw    $6,80($fp)
lw    $7,84($fp)
jal   EscolheMovimentoJogador # Chamada da função EscolheMovimentoJogador
nop

lw    $2,104($fp)

```

```

nop
move $5,$2
addiu $2,$fp,56
move $4,$2
jal MovimentaJogador          # Chamada da função MovimentaJogador
nop

lw $3,112($fp)
addiu $2,$fp,72
move $5,$3
move $4,$2
jal MovimentaJogador          # Chamada da função MovimentaJogador
nop

addiu $4,$fp,124
addiu $3,$fp,120
addiu $2,$fp,88
move $6,$4
move $5,$3
move $4,$2
jal MovimentaBola             # Chamada da função MovimentaBola
nop

addiu $2,$fp,116
sw $2,20($sp)
addiu $2,$fp,108
sw $2,16($sp)
lw $4,88($fp)
lw $5,92($fp)
lw $6,96($fp)
lw $7,100($fp)
jal VerificaPontuacao         # Chamada da função VerificaPontuacao
nop

beq $2,$0,$L49
nop

addiu $2,$fp,88
li $6,79                      # 0x4f
li $5,32                      # 0x20
move $4,$2
jal InicializaBola             # Chamada da função InicializaBola
nop

lw $2,120($fp)
nop
subu $2,$0,$2
sw $2,120($fp)
$L49:
addiu $3,$fp,120
addiu $2,$fp,88
move $6,$3
move $5,$2
addiu $2,$fp,56
move $4,$2
jal Rebate                     # Chamada da função Rebate
nop

addiu $4,$fp,120
addiu $3,$fp,88
addiu $2,$fp,72
move $6,$4
move $5,$3
move $4,$2
jal Rebate                     # Chamada da função Rebate
nop

```

```
li    $4,65000          # 0xfde8
jal   usleep
nop

lui   $2,%hi($LC2)
addiu $4,$2,%lo($LC2)
jal   printf
nop

b     $L48
nop          # main - Fim
```