Marcus Blaisdell
CptS 440
Homework #12
December 6, 2018
Dr. Holder

1)
a)

G +1000	← 847.71	← 733.67
W -1000	↑ 571.77	↑ 636.99
→ 286.33	↑ 486.95	↑ 550.51

Begin by solving for the two locations adjacent to our locations of known utility:

U([2,3]) = R([2,3]) + (0.9)*[(0.8)*U([1,3]) + (0.1)*U([2,3]) + (0.1)*U([2,2])]
U([2,3]) = (-0.04) + (0.72)*(1000) + (0.09)*U([2,3]) + (0.09)*U([2,2])
U([2,3]) = (719.96) + (0.09)*U([2,3]) + (0.09)*U([2,2])
0 = (719.96) + (-0.91)*U([2,3]) + (0.09)*U([2,2])

U([2,2]) = R([2,2]) + (0.9)*[(0.8)*U([2,3]) + (0.1)*U([2,2]) + (0.1)*U([1,2])]
U([2,2]) = (-0.04) + (0.72)*U([2,3]) + (0.09)*U([2,2]) + (0.09)*(-1000)
U([2,2]) = (-90.04) + (0.72)*U([2,3]) + (0.09)*U([2,2])
0 = (-90.04) + (0.72)*U([2,3]) + (-0.91)*U([2,2])

2 equations, 2 unknowns, set the two equal to each other, solve for one term, substitute that solution into one of the equations to solve for the second term, use that answer to solve the first term:

(719.96) + (-0.91)*U([2,3]) + (0.09)*U([2,2]) = (-90.04) + (0.72)*U([2,3]) + (-0.91)*U([2,2])

(719.96) + (-0.91)*U([2,3]) + (0.09)*U([2,2]) + (90.04) - (0.72)*U([2,3]) + (0.91)*U([2,2]) = 0

(810) + (-1.63)*U([2,3]) + (1)*U([2,2]) = 0

Solve for U([2,2]):

U([2,2]) = (-810) + (1.63)*U([2,3])

Substitute into either of the equations to solve for U([2,3]):

0 = (719.96) + (-0.91)*U([2,3]) + (0.09)*[(-810) + (1.63)*U([2,3])]

0 = (719.96) + (-0.91)*U([2,3]) + (-72.9) + (0.1467)*U([2,3])

0 = (647.06) + (-0.7633)*U([2,3])

(0.7633)*U([2,3]) = (647.06)

U([2,3]) = (647.06) / (0.7633)

U([2,3]) = (847.71)

With U([2,3]) known, use either of the two original equations to solve for U([2,2]):

0 = (-90.04) + (0.72)*(847.71) + (-0.91)*U([2,2])

0 = (-90.04) + (610.3512) + (-0.91)*U([2,2])

0 = (520.3112) + (-0.91)*U([2,2])

(0.91)*U([2,2]) = (520.3112)

U([2,2]) = (520.3112) / (0.91)

U([2,2]) = (571.77)

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Next, use the next two adjacent locations to the two we have just calculated:

U([3,3]) = R([3,3]) + (0.9)*[(0.8)*U([2,3]) + (0.1)*U([3,3]) + (0.1)*U([3,2])]

U([3,3]) = (-0.04) + (0.72)*(847.71) + (0.09)*U([3,3]) + (0.09)*U([3,2])

U([3,3]) = (610.3112) + (0.09)*U([3,3]) + (0.09)*U([3,2])

0 = (610.3112) + (-0.91)*U([3,3]) + (0.09)*U([3,2])

U([3,2]) = R([3,2]) + (0.9)*[(0.8)*U([3,3]) + (0.1)*U([3,2]) + (0.1)*U([2,2])]

U([3,2]) = (-0.04) + (0.72)*U([3,3]) + (0.09)*U([3,2]) + (0.09)*(571.77)

U([3,2]) = (51.4193) + (0.72)*U([3,3]) + (0.09)*U([3,2])

0 = (51.4193) + (0.72)*U([3,3]) + (-0.91)*U([3,2])

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(610.3112) + (-0.91)*U([3,3]) + (0.09)*U([3,2]) = (51.4193) + (0.72)*U([3,3]) + (-0.91)*U([3,2])

(610.3112) + (-0.91)*U([3,3]) + (0.09)*U([3,2]) + (-51.4193) - (0.72)*U([3,3]) + (0.91)*U([3,2]) = 0

(558.8919) + (-1.63)*U([3,3]) + (1)*U([3,2]) = 0

Solve for U([3,3]):

(1.63)*U([3,3]) = (558.8919) + (1)*U([3,2])

U([3,3]) = (558.8919) + (1)*U([3,2]) / (1.63)

Substitute into either equation:

0 = (610.3112) + (-0.91)*[(558.8919) + (1)*U([3,2]) / (1.63)] + (0.09)*U([3,2])

0 = (610.3112) + [(-508.591629) + (-0.91)*U([3,2]) / (1.63)] + (0.09)*U([3,2])

0 = (994.807) + (-508.592) + (-0.91)*U([3,2]) + (0.1467)*U([3,2]) / (1.63)

0 = (994.807) + (-508.592) + (-0.91)*U([3,2]) + (0.1467)*U([3,2])

0 = (486.215) + (-0.7633)*U([3,2])

(0.7633)*U([3,2]) = (486.215)

U([3,2]) = (486.215) / (0.7633)

U([3,2]) = (636.99)

0 = (51.4193) + (0.72)*U([3,3]) + (-0.91)*(636.99)

0 = (-528.242) + (0.72)*U([3,3])

(0.72)*U([3,3]) = (528.242)

U([3,3]) = (528.242) / (0.72)

U([3,3]) = (733.67)

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U([1,1]) = R([1,1]) + (0.9)*[(0.8)*U([2,1]) + (0.1)*U([1,1]) + (0.1)*U([1,2])]

U([1,1]) = (-0.04) + (0.72)*U([2,1]) + (0.09)*U([1,1]) + (0.09)*(-1000)

U([1,1]) = (-90.04) + (0.72)*U([2,1]) + (0.09)*U([1,1])

0 = (-90.04) + (0.72)*U([2,1]) + (-0.91)*U([1,1])

Neither U([2,1]) or U([1,1]) is known, solve for them first:

U([2,1]) = R([2,1]) + (0.9)*[(0.8)*U([2,2]) + (0.1)*U([1,1]) + (0.1)*U([3,1])]

U([2,1]) = (-0.04) + (0.72)*(571.77) + (0.09)*U([1,1]) + (0.09)*U([3,1])

U([2,1]) = (411.6344) + (0.09)*U([1,1]) + (0.09)*U([3,1])

0 = (411.6344) + (0.09)*U([1,1]) + (0.09)*U([3,1]) – (1)U([2,1])

Three unknowns

U([3,1]) = R([3,1]) + (0.9)*[(0.8)*U([3,2]) + (0.1)*U([3,1]) + (0.1)*U([2,1])]

U([3,1]) = (-0.04) + (0.72)*(636.99) + (0.09)*U([3,1]) + (0.09)*U([2,1])

U([3,1]) = (458.5928) + (0.09)*U([3,1]) + (0.09)*U([2,1])

0 = (458.5928) + (-0.91)*U([3,1]) + (0.09)*U([2,1])

2 unknowns, no complementary equation, use these three to solve for 3 equations, 3 unknowns:

Solve for U([1,1]):

(0.91)*U([1,1]) = (-90.04) + (0.72)*U([2,1])

U([1,1]) = (-90.04) + (0.72)*U([2,1]) / (0.91)

Use to eliminate U([1,1]) in the only other equation that has it:

0 = (411.6344) + (0.09)*[(-90.04) + (0.72)*U([2,1]) / (0.91)] + (0.09)*U([3,1]) – (1)U([2,1])

0 = (411.6344) + [(-8.1036) + (0.0648)*U([2,1]) / (0.91)] + (0.09)*U([3,1]) – (1)U([2,1])

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0 = [(374.587) + (-8.1036) + (0.0648)*U([2,1]) + (0.0819)*U([3,1]) – (0.91)U([2,1])] / (0.91)

0 = (366.4834) + (-0.8452)*U([2,1]) + (0.0819)*U([3,1])

We now have 2 equations with 2 complementary unknowns:

(458.5928) + (-0.91)*U([3,1]) + (0.09)*U([2,1]) = (366.4834) + (-0.8452)*U([2,1]) + (0.0819)*U([3,1])

(458.5928) + (-0.91)*U([3,1]) + (0.09)*U([2,1]) - (366.4834) + (0.8452)*U([2,1]) - (0.0819)*U([3,1]) = 0

(92.1094) + (-0.9919)*U([3,1]) + (0.9352)*U([2,1]) = 0

Solve for U([3,1]):

(0.9919)*U([3,1]) = (92.1094) + (0.9352)*U([2,1])

U([3,1]) = [(92.1094) + (0.9352)*U([2,1])] / (0.9919)

Substitute into either equation:

0 = (458.5928) + (-0.91)*([(92.1094) + (0.9352)*U([2,1])] / (0.9919)) + (0.09)*U([2,1])

0 = (458.5928) + ([(-83.81956) + (-0.851)*U([2,1])] / (0.9919)) + (0.09)*U([2,1])

0 = [(454.878) + (-83.81956) + (-0.851)*U([2,1]) + (0.089)*U([2,1])] / (0.9919)

0 = (371.058) + (-0.762)*U([2,1])

(0.762)*U([2,1]) = (371.058)

U([2,1]) = (371.058) / (0.762)

U([2,1]) = (486.95)

Use to solve:

0 = (366.4834) + (-0.8452)*U([2,1]) + (0.0819)*U([3,1])

0 = (366.4834) + (-0.8452)*(486.95) + (0.0819)*U([3,1])

0 = (-45.0867) + (0.0819)*U([3,1])

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U([3,1]) = (45.0867)

U([3,1]) = (45.0867) / (0.0819)

U([3,1]) = (550.51)

And:

0 = (-90.04) + (0.72)*U([2,1]) + (-0.91)*U([1,1])

0 = (-90.04) + (0.72)*(486.95) + (-0.91)*U([1,1])

0 = (260.564) + (-0.91)*U([1,1])

(0.91)*U([1,1]) = (260.564)

U([1,1]) = (260.564) / (0.91)

U([1,1]) = (286.33)

b)

Temporal difference Q-learning:

$$U^{\pi}(s) = U^{\pi}(s) + \alpha(R(s) + \gamma U^{\pi}(s`) - U^{\pi}(s))$$

α = 1
γ = 0.9

5 executions of sequence: Right, Up, Up, Left (starting from [1,1])

Pass 1:

[1,1]:
$U^{\pi}([1,1]) = U^{\pi}([1,1]) + (1)((-0.04) + (0.9)* U^{\pi}([2,1]) - U^{\pi}([1,1]))$
$U^{\pi}([1,1]) = 0 + (1)((-0.04) + (0.9)* (0) – (0))$

$U^{\pi}([1,1]) = (-0.04)$

[2,1]:
$U^{\pi}([2,1]) = U^{\pi}([2,1]) + (1)((-0.04) + (0.9)* U^{\pi}([2,2]) - U^{\pi}([2,1]))$
$U^{\pi}([2,1]) = (0) + (1)((-0.04) + (0.9)*(0) - (0))$

$U^{\pi}([2,1]) = (-0.04)$

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[2,2]:
$U^{\pi}([2,2]) = U^{\pi}([2,2]) + (1)((-0.04) + (0.9)^{*} U^{\pi}([2,3]) - U^{\pi}([2,2]))$
$U^{\pi}([2,2]) = (0) + (1)((-0.04) + (0.9)^{*}(0) - (0))$
$U^{\pi}([2,2]) = 0 + (1)((-0.04) + (0.9)^{*} (0) – (0))$

$U^{\pi}([2,2]) = (-0.04)$

[2,3]:
$U^{\pi}([2,3]) = U^{\pi}([2,3]) + (1)((-0.04) + (0.9)^{*} U^{\pi}([3,3]) - U^{\pi}([2,3]))$
$U^{\pi}([2,3]) = (0) + (1)((-0.04) + (0.9)^{*}(1000) - (0))$
$U^{\pi}([2,3]) = 0 + (1)((-0.04) + (900) – (0))$

$U^{\pi}([2,3]) = (899.96)$

[1,3]:
Terminal state, U([3,3]) = 1000

$U^{\pi}[1,1] = -0.04$
$U^{\pi}[2,1] = -0.04$
$U^{\pi}[2,2] = -0.04$
$U^{\pi}[2,3] = 899.96$
$U^{\pi}[1,3] = 1000$

Pass 2:

[1,1]:
$U^{\pi}([1,1]) = U^{\pi}([1,1]) + (1)((-0.04) + (0.9)^{*} U^{\pi}([2,1]) - U^{\pi}([1,1]))$
$U^{\pi}([1,1]) = (-0.04) + (1)((-0.04) + (0.9)^{*} (-0.04) - (-0.04))$

$U^{\pi}([1,1]) = -0.076$

[2,1]:
$U^{\pi}([2,1]) = U^{\pi}([2,1]) + (1)((-0.04) + (0.9)^{*} U^{\pi}([2,2]) - U^{\pi}([2,1]))$
$U^{\pi}([2,1]) = (-0.04) + (1)((-0.04) + (0.9)^{*} (-0.04) - (-0.04))$

$U^{\pi}([2,1]) = -0.076$

[2,2]:

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$U^{\pi}([2,2]) = U^{\pi}([2,2]) + (1)((-0.04) + (0.9)* U^{\pi}([2,3]) - U^{\pi}([2,2]))$
$U^{\pi}([2,2]) = (-0.04) + (1)((-0.04) + (0.9)* (899.96) - (-0.04))$

$U^{\pi}([2,2]) = 809.924$

[2,3]:
$U^{\pi}([2,3]) = U^{\pi}([2,3]) + (1)((-0.04) + (0.9)* U^{\pi}([3,3]) - U^{\pi}([2,3]))$
$U^{\pi}([2,3]) = (899.96) + (1)((-0.04) + (0.9)* (1000) - (899.96))$

$U^{\pi}([2,3]) = (899.96)$

[1,3]:
Terminal state, U([3,3]) = 1000

$U^{\pi}[1,1] = -0.076$
$U^{\pi}[2,1] = -0.076$
$U^{\pi}[2,2] = 809.924$
$U^{\pi}[2,3] = 899.96$
$U^{\pi}[1,3] = 1000$

Pass 3:

[1,1]:
$U^{\pi}([1,1]) = U^{\pi}([1,1]) + (1)((-0.04) + (0.9)* U^{\pi}([2,1]) - U^{\pi}([1,1]))$
$U^{\pi}([1,1]) = (-0.076) + (1)((-0.04) + (0.9)* (-0.076) - (-0.076))$

$U^{\pi}([1,1]) = -0.1084$

[2,1]:
$U^{\pi}([2,1]) = U^{\pi}([2,1]) + (1)((-0.04) + (0.9)* U^{\pi}([2,2]) - U^{\pi}([2,1]))$
$U^{\pi}([2,1]) = (-0.076) + (1)((-0.04) + (0.9)* (809.924) - (-0.076))$

$U^{\pi}([2,1]) = 728.8916$

[2,2]:
$U^{\pi}([2,2]) = U^{\pi}([2,2]) + (1)((-0.04) + (0.9)* U^{\pi}([2,3]) - U^{\pi}([2,2]))$
$U^{\pi}([2,2]) = (809.924) + (1)((-0.04) + (0.9)* (899.96) - (809.924))$

$U^{\pi}([2,2]) = 809.924$

[2,3]:
$U^{\pi}([2,3]) = U^{\pi}([2,3]) + (1)((-0.04) + (0.9)* U^{\pi}([3,3]) - U^{\pi}([2,3]))$
$U^{\pi}([2,3]) = (899.96) + (1)((-0.04) + (0.9)* (1000) - (899.96))$

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$U^{\pi}([2,3]) = 899.96$

[1,3]:
Terminal state, U([3,3]) = 1000

$U^{\pi}[1,1] = -0.1084$
$U^{\pi}[2,1] = 728.8916$
$U^{\pi}[2,2] = 809.924$
$U^{\pi}[2,3] = 899.96$
$U^{\pi}[1,3] = 1000$

Pass 4:

[1,1]:
$U^{\pi}([1,1]) = U^{\pi}([1,1]) + (1)((-0.04) + (0.9)* U^{\pi}([2,1]) - U^{\pi}([1,1]))$
$U^{\pi}([1,1]) = (-0.1084) + (1)((-0.04) + (0.9)* (728.8916) - (-0.1084))$

$U^{\pi}([1,1]) = 655.96$

[2,1]:
$U^{\pi}([2,1]) = U^{\pi}([2,1]) + (1)((-0.04) + (0.9)* U^{\pi}([2,2]) - U^{\pi}([2,1]))$
$U^{\pi}([2,1]) = (728.8916) + (1)((-0.04) + (0.9)* (809.924) - (728.8916))$

$U^{\pi}([2,1]) = 728.8916$

[2,2]:
$U^{\pi}([2,2]) = U^{\pi}([2,2]) + (1)((-0.04) + (0.9)* U^{\pi}([2,3]) - U^{\pi}([2,2]))$
$U^{\pi}([2,2]) = (809.924) + (1)((-0.04) + (0.9)* (899.96) - (809.924))$

$U^{\pi}([2,2]) = 809.924$

[2,3]:
$U^{\pi}([2,3]) = U^{\pi}([2,3]) + (1)((-0.04) + (0.9)* U^{\pi}([3,3]) - U^{\pi}([2,3]))$
$U^{\pi}([2,3]) = (899.96) + (1)((-0.04) + (0.9)* (1000) - (899.96))$

$U^{\pi}([2,3]) = 899.96$

[1,3]:
Terminal state, U([3,3]) = 1000

$U^{\pi}[1,1] = 655.96$

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$U^{\pi}[2,1] = 728.8916$
$U^{\pi}[2,2] = 809.924$
$U^{\pi}[2,3] = 899.96$
$U^{\pi}[1,3] = 1000$

Pass 5:

[1,1]:
$U^{\pi}([1,1]) = U^{\pi}([1,1]) + (1)((-0.04) + (0.9)* U^{\pi}([2,1]) - U^{\pi}([1,1]))$
$U^{\pi}([1,1]) = (655.96) + (1)((-0.04) + (0.9)* (728.8916) - (655.96))$

$U^{\pi}([1,1]) = 655.96$

[2,1]:
$U^{\pi}([2,1]) = U^{\pi}([2,1]) + (1)((-0.04) + (0.9)* U^{\pi}([2,2]) - U^{\pi}([2,1]))$
$U^{\pi}([2,1]) = (728.8916) + (1)((-0.04) + (0.9)* (809.924) - (728.8916))$

$U^{\pi}([2,1]) = 728.8916$

[2,2]:
$U^{\pi}([2,2]) = U^{\pi}([2,2]) + (1)((-0.04) + (0.9)* U^{\pi}([2,3]) - U^{\pi}([2,2]))$
$U^{\pi}([2,2]) = (809.924) + (1)((-0.04) + (0.9)* (899.96) - (809.924))$

$U^{\pi}([2,2]) = 809.924$

[2,3]:
$U^{\pi}([2,3]) = U^{\pi}([2,3]) + (1)((-0.04) + (0.9)* U^{\pi}([3,3]) - U^{\pi}([2,3]))$
$U^{\pi}([2,3]) = (899.96) + (1)((-0.04) + (0.9)* (1000) - (899.96))$

$U^{\pi}([2,3]) = 899.96$

[1,3]:
Terminal state, U([3,3]) = 1000

$U^{\pi}[1,1] = -0.13756$
$U^{\pi}[2,1] = -0.13756$
$U^{\pi}[2,2] = 809.924$
$U^{\pi}[2,3] = 899.96$
$U^{\pi}[1,3] = 1000$

Cell	Pass 1	Pass 2	Pass 3	Pass 4	Pass 5
[1,1]	-0.04	-0.076	-0.1084	655.96	655.96

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[2,1]	-0.04	-0.076	728.8916	728.8916	728.8916
[2,2]	-0.04	809.924	809.924	809.924	809.924
[2,3]	899.96	899.96	899.96	899.96	899.96
[3,3]	1000	1000	1000	1000	1000

2)

a)
P(Class) = # times hungry/not hungry appears as the classification out of the total number of classifications:

P(Class = hungry) = 600/1000 = 0.6

P(Class = not hungry) = 400/1000 = 0.4

b)
m = "the wumpus is not hungry"
bigrams:
the wumpus
wumpus is
is not
not hungry

By Bayes rule:

P(Class = hungry | Message = m) = P(Message = m | Class = hungry) / P(Class = hungry)
= P(P(wumpus|the) | class = hungry * P(is|wumpus) | class = hungry * P(not|is) | class = hungry * P(hungry|not) | class = hungry) / P(Class = hungry)

P(wumpus|the) = 300/1000 = 0.3
P(is|wumpus) = 90/1000 = 0.09
P(not|is) = 60/1000 = 0.06
P(hungry|not) = 100/1000 = 0.1

0.3 * 0.09 * 0.06 * 0.1 = 0.000162

P(message = m | class = hungry) = 0.000162
P(class = hungry) = 0.6
0.000162 / 0.6 = 0.00027

P(class = hungry | message = m) = 0.00027

c)

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P(Class = not hungry | Message = m) = P(Message = m | Class = not hungry) / P(Class = not hungry)
= P(P(wumpus|the) | class = not hungry * P(is|wumpus) | class = not hungry * P(not|is) | class = not hungry * P(hungry|not) | class = not hungry) / P(Class = not hungry)

P(wumpus|the)	= 150/1000	= 0.15
P(is|wumpus)	= 40/1000	= 0.04
P(not|is)	= 60/1000	= 0.06
P(hungry|not)	= 200/1000	= 0.2

0.15 * 0.04 * 0.06 * 0.2 = 0.000072

P(message = m | class = not hungry) = 0.000072
P(class = not hungry) = 0.4

0.000072 / 0.4 = 0.00018

P(class = not hungry | message = m) = 0.00018

d)

P(class = hungry | message = m) = 0.00027 > P(class = not hungry | message = m) = 0.00018

The more likely class, given this corpus, is the classification is “not hungry” for message m.

2)

a)

```
                    S
             /              \
          NP                 VP
       /   |           /       |
article  noun   verb    adjective
   |         |        |          |
“the     agent   is        alive”
```

b)

```
                    S
               /             \
             /                VP
           /           /       |
          NP      VP       |                 X                       X                        X
       /   |           |         |                NP                      |                        NP
                                              /   |                         |                       /   |
article  noun    verb    adverb article  noun             conjunction      article  noun
```

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```
  |        |      |          |       |        |                 |                |          |
"the     agent   is        near    the     wumpus            and              the       gold"
```

Sentence cannot be parsed, it is not consistent with (accepted) by the grammar.

c)

```
                                      S
                  /                                     \
                 /                                      VP
                /                /                                  \
               /             VP                                      PP
              /          /              \                       /        \
           NP       VP                NP                       /          NP
        /   |           |           /    |                    /         /    \
article  noun    verb     article  noun             preposition    digit    digit
  |          |          |       |          |            |                 |          |
"the     agent   shoots  the      wumpus          in                1         3"
```

d)

```
                                              S
                                   /
                             NP                                      \
                  /                       \                           \
                 /                      RelativeClause          VP
                /                           /        |            /      \
           NP                              /        VP          VP        \
         /   |                             /          |            |           \
article  noun                relativePronoun     verb          verb     adjective
  |        |                     |                     |             |            |
"the     wumpus              who                  stinks        is        dead"
```

4)

input sequence: [C_2, C_3, C_3, C_4, C_5, C_6, C_7]

V1, onset = P(C2|onset)P(onset)
= (0.5)(1.0) = 0.5
V1, mid = P(C2|mid) = 0
V1, end = P(C2|end) = 0
V1, final = 0

-

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V2, onset = P(C3|onset)max{[P(onset|onset)V1, onset], 0,0,0}
= (0.3)[(0.6)(0.5)] = 0.09
V2, mid = P(C3|mid)max{[P(mid|onset)V1, onset, P(mid|mid)V1, mid, 0,0]}
= (0.3){[(0.4)(0.5)], [(0.5)(0)]} = {0.06, 0}
V2, end = P(C3|end) = 0
V2, final = 0

-

V3, onset = P(C3|onset)max{[P(onset|onset)V2, onset, 0, 0, 0]}
= (0.3)[(0.6)(0.09)] = 0.0162
V3, mid = P(C3|mid)max {[P(mid|onset)V2, onset, P(mid|mid)V2, mid], 0, 0}
= (0.3){[(0.4)(0.09)], [(0.5)(0.06)]} = {0.0108, 0.009}
V3, end = P(C3|end) = 0
V3, final = 0

-

V4, onset = P(C4|onset) = 0
V4, mid = P(C4|mid)max{[P(mid|onset)V3, onset, P(mid|mid)V3, mid], 0, 0}
= (0.3){[(0.4)(0.0162)], [(0.5)(0.0108)]} = {0.00243, 0.00162}
V4, end = P(C4|end)max{[P(end|mid)V3, mid, P(end|end)V3, end], 0}
= (0){[()()], [()()]} {0, 0}
V4, final = 0

-

V5, onset = P(C5|onset) = 0
V5, mid = P(C5|mid)max{[P(mid|onset)V4, onset, P(mid|mid)V4, mid], 0,0}
= (0.4){[(0.4)(0)], [(0.5)(0.00243)]} = {0, 0.000486}
V5, end = P(C5|end)max{[P([end|mid]V4, mid), P(end|end)V4, end, 0}
= (0.2){[(0.5)(0.00243)], [(0.3)(0)]} = {0.000243, 0}
V5, final = 0

-

V6, onset = P(C6|onset) = 0
V6, mid = P(C6|mid) = 0
V6, end = P(C6|end)max{[P(end|mid)V5, mid, P(end|end)V5, end], 0}
= (0.4){[(0.5)(0.000486)], [(0.3)(0.000243)]} = {0.0000972, 0.00002916}
V6, final = 0

-

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$V7, onset = P(C7|onset) = 0$
$V7, mid = P(C7|mid) = 0$
$V7, end = P(C7|end)\max\{[P(end|mid)V6, mid, P(end|end)V6, end], 0\}$
$= (0.4)\{[(0.5)(0)], [(0.3)(0.0000972)]\} = \{0, 0.000011664\}$
$V7, final = 0$

$P(final|end)V7, end$
$= (0.7)(0.000011664)$
$= 0.0000081648$
$= 8.16 \times 10^{-6}$

$P(HMM) = 8.16 \times 10^{-6}$

Most probable path:
Onset, onset, onset, mid, mid, end, end, final