Neuromorphic Modeling the Effects of Dopamine Uptake and Availability

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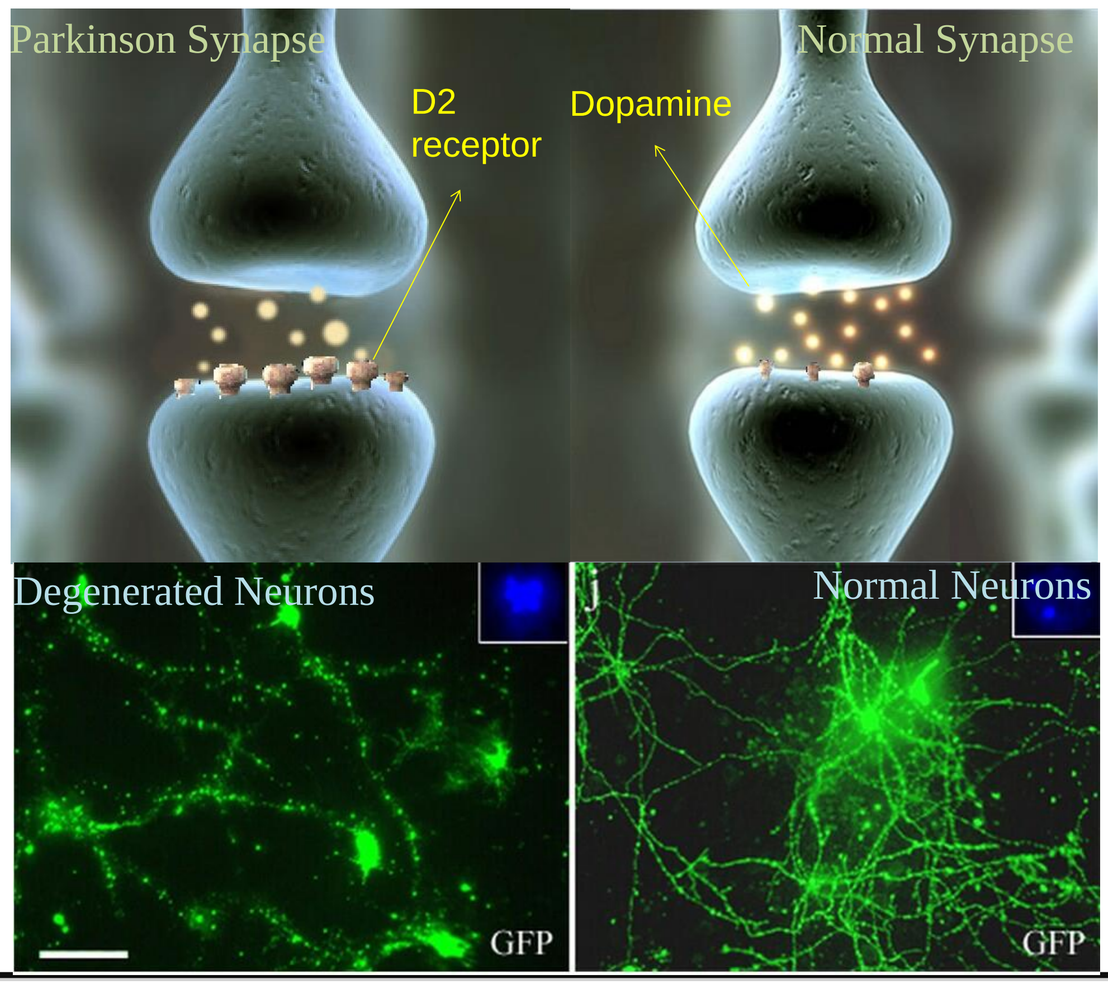
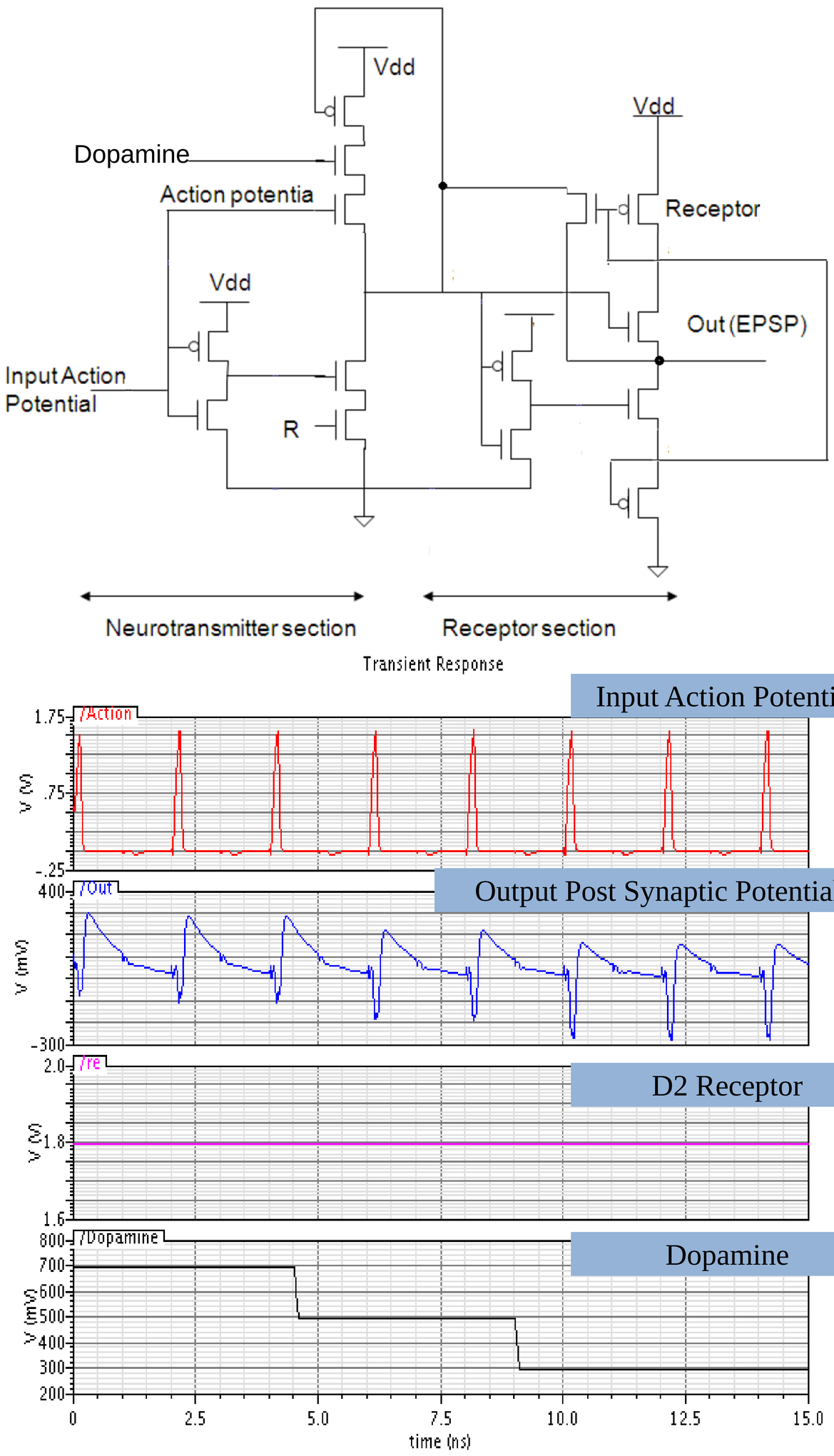
Motivation

- Neurological disease, including Parkinson's Disease(PD), affects as many as one billion people worldwide, estimated in 2006 by WHO. Modern treatments are effective at managing the early motor symptoms of PD, but the drugs eventually become ineffective at treating the symptoms. However, advancing technology, such as deep brain stimulation, has been used to reduce the motor symptoms when drugs are ineffective. This shows the significant potential of electrical technology using in neurological disorders.
- Neuromorphic engineering is used to build electronic circuits modeling neurons and it has been implemented in building implantable chips for the Peripheral Nervous System, such as artificial retina and cochlear implant. The application of neuromorphic chips for Central Nervous System disorders is our ultimate target.

Degeneration in Parkinson's Disease



Neuromorphic Circuit



Discussion & Future Work

- In Parkinson's disease, the loss of the dopamine D2 receptors (DA-D2R) is reportedly due to the degeneration of dopaminergic neurons, whereas the increase in DA-D2Rs results from increased expression on remaining dopaminergic terminals and/or increased synthesis within striatopallidal neurons or cholinergic interneurons. The ultimate loss of DA-D2Rs induces a disconnection between presynapse and postsynapse. Failure of dopamine to be uptaken in presynaptic vesicles is another related mechanism found in Parkinsons. we shut off the presynaptic circuit to mimic the disconnection. As the presynaptic circuit shuts down the synapse, the compensatory mechanism begins to generate more DA-D2Rs to maintain the connection. We use a compensatory circuit to allow subthreshold voltage conduction. In a circuit including multiple synapses, if there is enough subthreshold voltage, the connection can still exist.
- In conclusion, we are capable of simulating a portion of fundamental processing in Parkinson's disease by neuromorphic engineering and achieve a similar output signal to biological neural pulses. In the future, a complete circuit model will help us to understand the complexities of Parkinson's disease integrating multiple effects, theory, or even treatment.Eventually, a bioelectronic neuromorphic circuit with partial normal function may be an implantable treatment for incurable neurology disease, such as Parkinson's disease.

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