Electronic Supplementary Material (ESI) for Chemical Science.

Ternary DNA Computing Using 3×3 Multiplication

Matrices - Supporting Information

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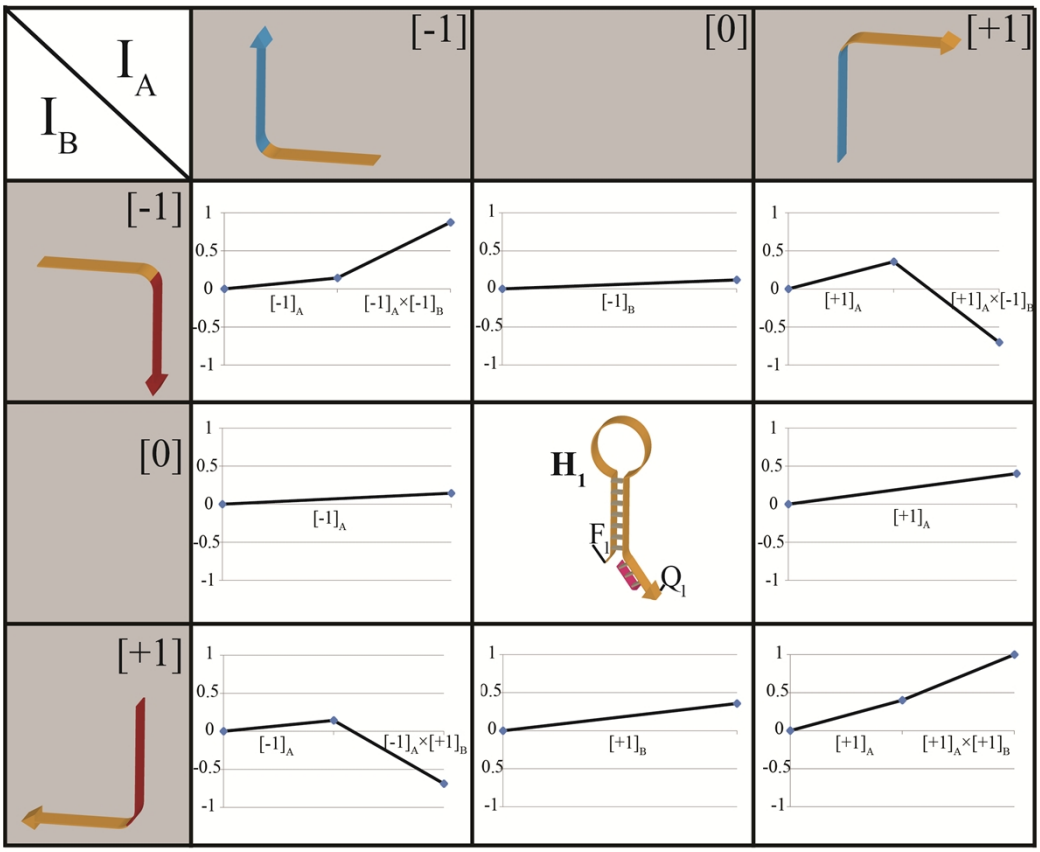

Figure S1. Fluorescence changes corresponding to the stepwise treatment of the computational module with the respective inputs to yield the different modules states.

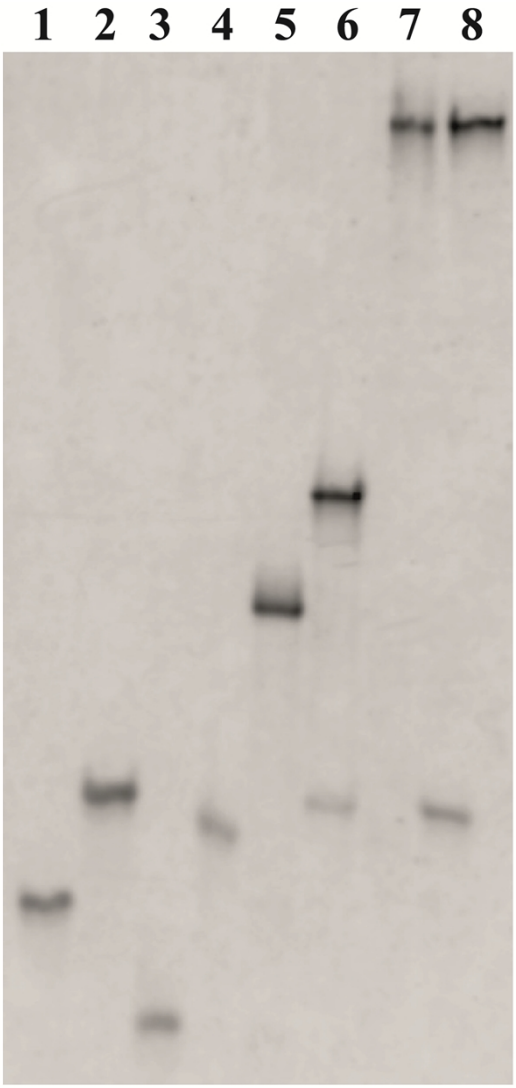

Figure S2. Native Polyacrylamide Gel-electrophoresis results of the the three-valued inputs. Lanes: (1) $[+1]_A$ (2) $[-1]_A$ (3) $[+1]_B$ (4) $[-1]_B$ (5) $[-1]_A \times [-1]_B$ (6) $[+1]_A \times [+1]_B$ (7) $[+1]_A \times [-1]_B$ (8) $[-1]_A \times [+1]_B$. Note that the products $[-1]_A \times [-1]_B$ and $[+1]_A \times [+1]_B$ (z-shape) and the $[+1]_A \times [-1]_B$ and $[-1]_A \times [+1]_B$ (T-shape) show different migration rates due to difference in the secondary structures of the resulting shapes.

The gels consisted of 15% polyacrylamide (acrylamide/bis-acrylamide, 19:1) in a Tris-borate-EDTA (TBE) buffer solution that was purchased from Biological Industries Israel BEIT HAEMEK LTD. (Kibutz Beit-Haemek, Israel). The buffer included Tris base (89 mM, pH 7.9), boric acid (89 mM), and EDTA (ethylenediaminetetraacetic acid, 2 mM). A portion (2 μL) of each of the reaction mixtures was mixed with the loading dye and loaded onto the gel. The gels were run on a Hoefer SE 600 electrophoresis unit at room temperature (150V, constant voltage) for 6 h in 0.5×TBE buffer. After electrophoresis, the gels were stained with SYBR Gold nucleic acid gel stain (Invitrogen) and imaged.

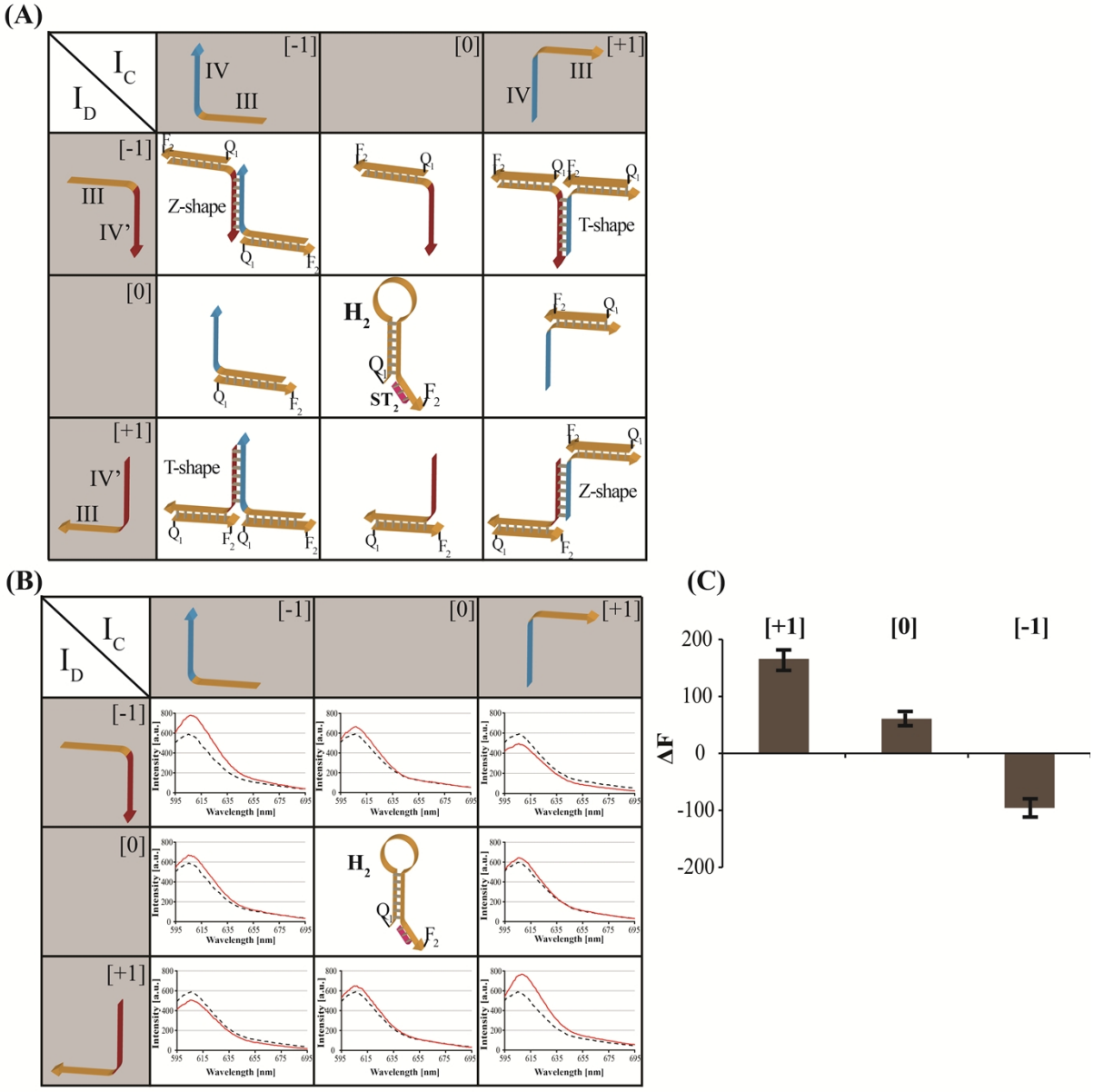

Figure S3. (A) Schematic interactions of the three-valued inputs I_A and I_B with the computational hairpin module, $\mathbf{H_2}$, to yield the 3x3 multiplication table. (B) Fluorescence spectra corresponding to the products generated upon interaction of the three-valued inputs with the hairpin computing module $\mathbf{H_2}$, modified with ROX. The fluorescence intensities of the system in comparison to the background fluorescence of the computing module represent the output of the states of the multiplication table (black dashed line – initial fluorescence spectra of the computing module; red continuous line – fluorescence spectra of the system subjected to the respective input values). (c) Fluorescence changes, ΔF, at λ=605 nm, in the form of bars presentation, corresponding to the output values [-1], [0], [+1]. Error bars were derived from N=4 experiments.

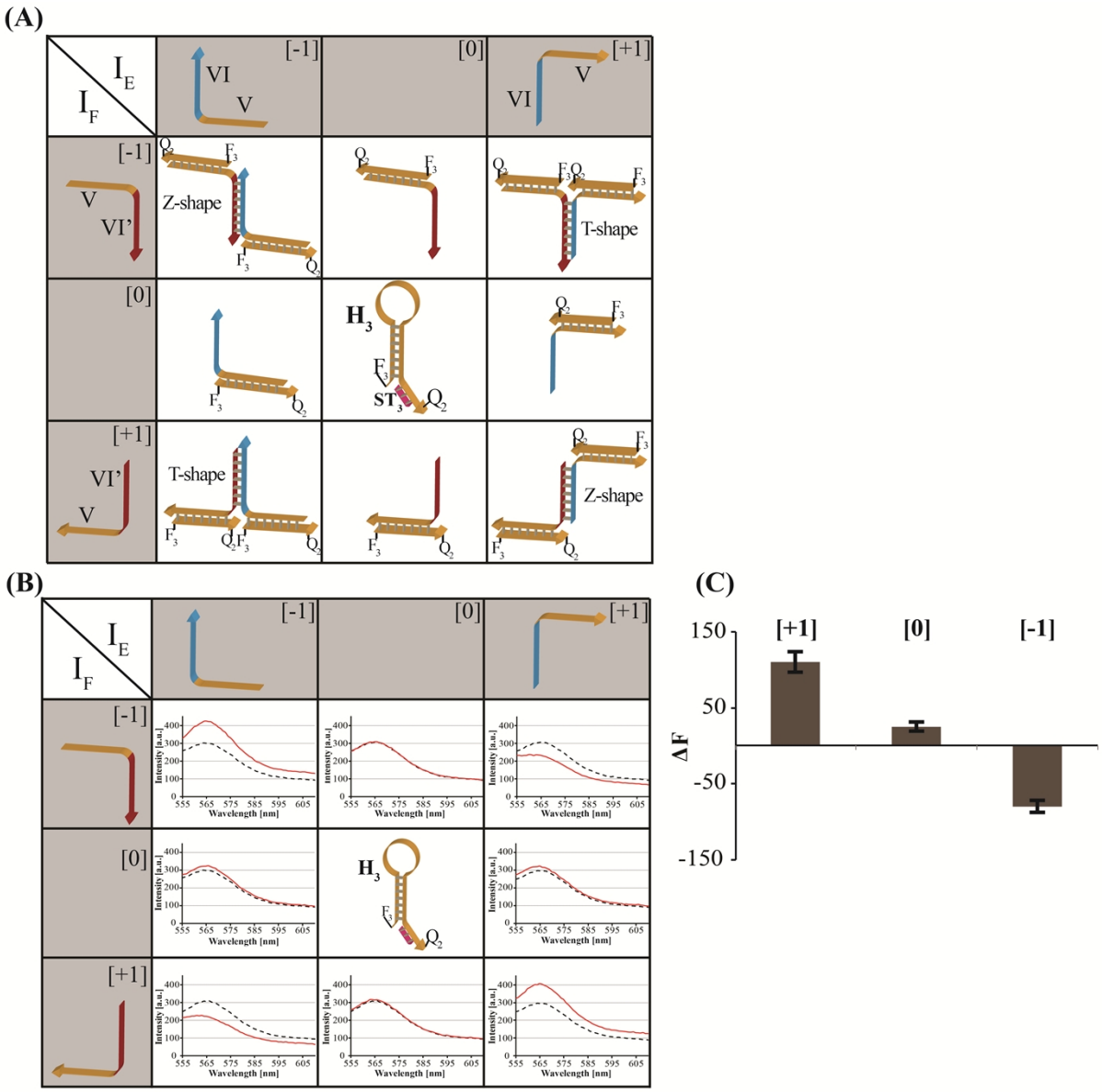

Figure S4. (A) Schematic interactions of the three-valued inputs I_A and I_B with the computational hairpin module, $\mathbf{H_3}$, to yield the 3x3 multiplication table. (B) Fluorescence spectra corresponding to the products generated upon interaction of the three-valued inputs with the hairpin computing module $\mathbf{H_3}$, modified with Cy3. The fluorescence intensities of the system in comparison to the background fluorescence of the computing module represent the output of the states of the multiplication table (black dashed line – initial fluorescence spectra of the computing module; red continuous line – fluorescence spectra of the system subjected to the respective input values). (c) Fluorescence changes, ΔF, at λ=560 nm, in the form of bars presentation, corresponding to the output values -1, 0, +1. Error bars were derived from N=4 experiments.

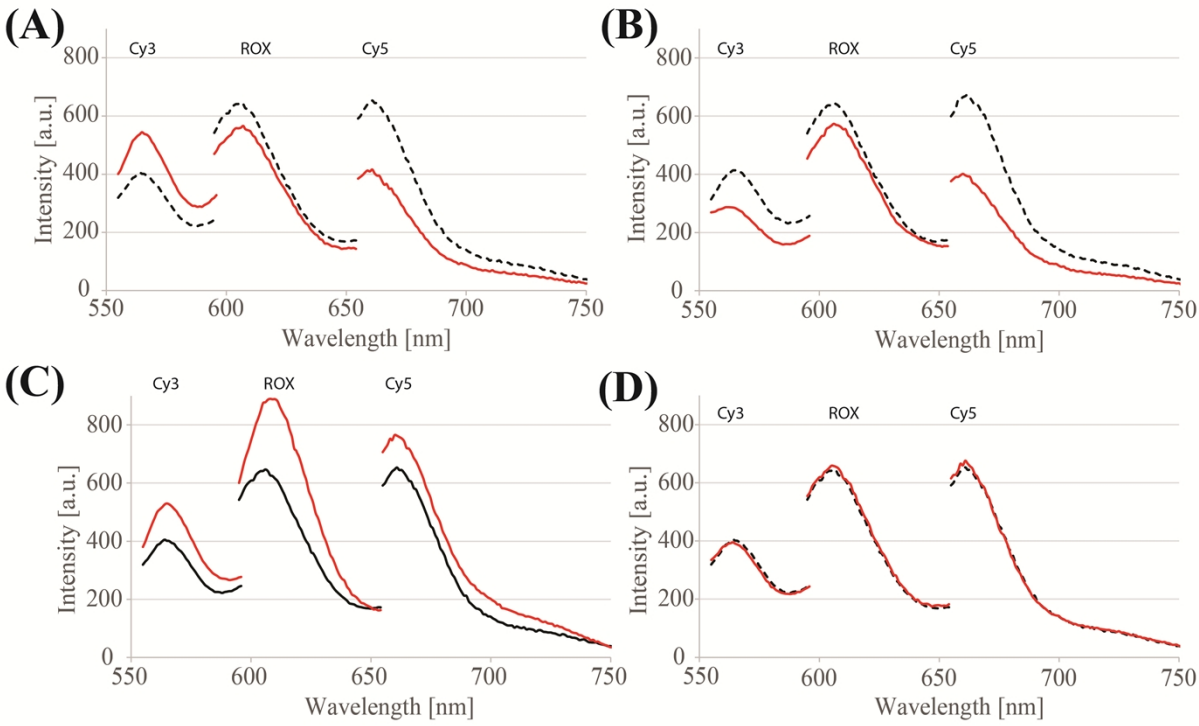

Figure S5. Examples of fluorescence spectra corresponding to the parallel computation of three multiplication tables. The fluorescence of each computational module provides the output of the product state in the table: (A) Fluorescence spectra corresponding to the parallel computing of the products Cy5:$[-1]_A \times [+1]_B$, ROX:$[+1]_C \times [-1]_D$ and Cy3:$[-1]_E \times [-1]_F$. (B) Fluorescence spectra corresponding to the parallel computing of the products Cy5:$[+1]_A \times [-1]_B$, ROX:$[-1]_C \times [+1]_D$ and Cy3:$[-1]_E \times [+1]_F$. C) Fluorescence spectra corresponding to the parallel computing of the products Cy5:$[-1]_A \times [-1]_B$, ROX:$[+1]_C \times [+1]_D$ and Cy3$[+1]_E \times [+1]_F$. (D) Fluorescence spectra corresponding to the parallel computing of the products Cy5:$[0]_A \times [-1]_B$, ROX:$[0]_C \times [0]_D$ and Cy3:$[0]_E \times [+1]_F$. (black dashed line – initial fluorescence spectra of the computing module; red continuous line – fluorescence spectra of the system subjected to