BILL, RECORD LECTURE!!!!

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Finite Ramsey Theorem For 3-Hypergraph: Better Bounds

Exposition by William Gasarch

February 20, 2025

Credit Where Credit is Due

The main theorem in these slides, in fact not just the 3-ary case but also the *a*-ary case, appeared in **Combinatorial Theorems on Classifications of Subsets of a Given Set** by Erdös and Rado (1952).

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Here is a link
https://www.cs.umd.edu/users/gasarch/TOPICS/
canramsey/ErdosRado2.pdf

Thm $(\forall a)(\forall k)$



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Look at all triples that have 1,2 in them.

Since every 3-subset has a color, harder to draw pictures so I won't :-(. Look at all triples that have 1,2 in them. COL(1,2,3) = R.

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COL(1,2,3) = R.
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COL(1, 2, 6) = R.
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COL(1, 2, n) = \mathbb{R}.
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We are given COL: $\binom{[n]}{3} \rightarrow [2]$.



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Now what? Discuss.

We have $H_1, x_1, x_2, c_{1,2}, H_2$

We have $H_1, x_1, x_2, c_{1,2}, H_2$ x_3 is the least element of H_2 .

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We have $H_1, x_1, x_2, c_{1,2}, H_2$ x_3 is the least element of H_2 . Discuss what to do next.

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We have H_s, x_1, \ldots, x_s and $\{c_{i,j} \colon 1 \leq i < j \leq s\}$

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$$\begin{split} |H_1| &= n \\ H_{s+1} \text{ takes } H_s \text{ and cuts it in half } s \text{ times.} \\ |H_{s+1}| &\geq \frac{1}{2^s} |H_s| \\ |H_{s+1}| &\geq \frac{1}{2^s} |H_s| = \frac{1}{2^s} \frac{1}{2^{s-1}} |H_{s-1}| = \frac{1}{2^{s+(s-1)}} |H_{s-1}|. \end{split}$$

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We have x_1, \ldots, x_s . For all $1 \leq i < j \leq s$ we have $c_{i,i}$. We have created a coloring $\text{COL}''({x_1,...,x_s}) \rightarrow [2]$. Apply 2-ary Ramsey to COL'' to get a homog set H, $|H| > \log s/2$. We later pick s such that $k \leq \log(s)/2$. Assume |H| = k. Assume the color of the homog set is \mathbf{R} . $H = \{x_{i_1} < x_{i_2} < \cdots < x_{i_k}\}$ Let a < b < c. Look at $COL(x_{i_2}, x_{i_3}, x_{i_5}, x_{i_6})$ Since $x_{i_a}, x_{i_b} \in H$, $COL(x_{i_a}, x_{i_b}, z) = \mathbb{R}$ for any surviving z. So $\operatorname{COL}(x_{i_2}, x_{i_k}, x_{i_c}) = \mathbf{R}$.

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$$k \leq \log s/2$$

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$$n \ge 2^{s^2/2} \ge 2^{2^{4k}}$$

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- d) See next slide for an example of how timing and luck played a major role.

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It is said **correctly** that the result is due to RDPM.