Liang, Y. D., Bethely, J., & Walia, G. S. (2021). Visualizing recursion using code and stack animation. *Journal of Computing Sciences in Colleges*, *37*(4), 41-49.

1. Introduction to Code Animation:

  - Code animation is a visual tool for tracing the execution of code.

  - The authors have developed more than 240 code animations for Java, C++, and Python.

  - The code animations have been integrated into Pearson's Revel interactive ebooks and have received positive reviews.

2. Effectiveness of Code Animation:

  - Studies have shown that code animations, particularly those that step through code execution, help students better understand programming concepts and replicate coding on their own.

  - Code animation has been demonstrated to be effective in teaching variables, selection statements, loops, methods, pass by value, and arrays.

3. The Challenge of Teaching Recursion:

  - Recursion is considered a challenging programming technique to teach because students often struggle to understand how it works behind the scenes.

  - Existing approaches to teaching recursion include algorithm animation, program visualization, and specialized software tools.

  - These approaches often lack web-based interactivity and fail to show the call stack.

4. Development of Code Animation for Recursion:

  - In response to instructor requests, the authors created code animations for recursion, specifically for non-tail recursion and tail recursion.

  - They emphasize the importance of recursion as a programming technique for solving inherently recursive problems efficiently.

5. Visualizing Recursion with Code Animation:

  - The paper describes a code animation for computing factorial using a recursive method, providing a step-by-step visualization of method calls and the call stack.

  - It highlights how this animation helps students understand how recursive methods are executed with activation records in the call stack.

6. Visualizing Tail Recursion with Code Animation:

- Another code animation is presented for computing factorial using a tail-recursive method.

   - The animation illustrates how tail recursion is efficient in terms of space and time, as it reuses activation records.

7. Evaluation of Code Animations:

   - Student surveys and test results indicate that code animations significantly enhance understanding of recursion and tail recursion.

   - The animations were shown to be particularly effective for teaching tail recursion.

8. Conclusions:

   - The paper concludes that code animations are valuable tools for helping students comprehend complex programming concepts, such as recursion.