DEEP TEJAS KARKHANIS

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INTERESTS

Machine Learning, Reinforcement Learning and Planning, Formal Methods

EDUCATION

Indian Institute of Technology, Bombay *Graduating 2020*
Pursuing B.Tech with Honors in Computer Science and Engineering

- GPA : 9.59/10.0 (after 7 semesters)
- Minor in Applied Statistics and Informatics

ACCEPTED PAPER

- Krishnendu Chatterjee, Martin Chmelík, **Deep Karkhanis**, Petr Novotný and Amélie Royer, *"Multiple-Environment Markov Decision Processes: Efficient Analysis and Applications"* 30th International Conference on Automated Planning and Scheduling, *ICAPS 2020*

RESEARCH EXPERIENCE

Tractable Policy Iteration for POMDPs **IIT Bombay**
B.Tech Project | Prof. Shivaram Kalyanakrishnan *Ongoing since Fall 2018*

- Made policy iteration in POMDPs more controllable by regulating the update of Finite-State Controllers (FSCs) in Hansen's algorithm. An FSC encodes a POMDP policy.
- Selectively improved a subset of Finite-State Controller nodes as opposed to updating all of them, in the Policy Improvement part of the algorithm
- Designed an algorithm to locally combine controller nodes, in order to decrease controller size without impairing the policy
- Found policies with 20% higher expected rewards, 70% of the times for the same Controller size.

Multiple Environment MDPs: Efficient Analysis and Applications **IST Austria**
Research Internship | Prof. Krishnendu Chatterjee *Summer 2018*

- Improved the PAMCP (Past-Aware POMCP) algorithm to create an online solver for MEMDPs and established its superiority over conventional POMCP or PBVI based POMDP solvers
- Exploited the sparse transitions in MEMDPs to have faster belief updates [O(n) as opposed to $O(n^2)$]
- The solver exhibited higher success rates and crash-less navigation on the Hallway and Rock-Sampling benchmarks.
- The solver was 50 times faster and 20 times more accurate in detecting high risk environments.

Bounded Model Checking in MDPs **RWTH Aachen**
Research Internship | Prof. Dr. Ir. Joost-Pieter Katoen *Summer 2019*

- Used Bounded Model Checking for finding the existence of Finite Horizon MDP policies which ensure that the k-step reachability probability of a target state exceeds a given threshold.
- Designed a succinct CNF encoding for Markov Chains using the transition probabilities BDD (Binary Decision Diagram) and Knuth-Yao Encoding.
- Adopted Model Counting for evaluating the k-step reachability probability for the Markov Chain CNF and used Policy Iteration for incrementally arriving at an optimal policy for the MDP.
- The new CNF-encoding induces 10 times faster solving than traditional transition-table encodings

Functional significance checking in Noisy Gene Regulatory Networks **IIT Bombay**
Research Project | Prof. Supratik Chakraborty *Ongoing since August 2019*

- Used QSAT methods to find gene-regulatory pathways in networks having bounded amount of noise
- Encoded gene-expression profiles as edge-labelled graphs, to define a pareto-optimization problem.
- Reduced the functional significance checking problem of a gene to a single 2-QBF-solver call, by looking for explanation sub-graphs within a relaxation window.
- Analysed the pareto-optimal curves on microarray data obtained from cancer cell-line experiments

Restoring degraded Cave-Paintings using Deep-Image Priors **IIT Bombay**
Research Project | Prof. Masaaki Nagahara *Spring 2019*

- Optimized the method of image inpainting using deep image prior for restoring cave paintings
- Used a 4-layer CNN in conjunction with a GAN to identify pixels in the inpainting region which actually represent unscathed parts of the painting
- Successfully restored the depicted ornaments and facial features including facial expressions of people and deities in multiple paintings in **Ajanta Caves, Mumbai**
- Achieved results very close to ground-truth (tested on paintings whose older images were available)

AWARDS AND ACADEMIC ACHIEVEMENTS

- Awarded the **Undergraduate Research Award** for distinguished research in POMDP solvers *2019*
- Received the **Institute Academic Excellence Award** from the Dean of Academic Affairs for securing **Institute Rank 1** at the end of first year *2017*
- Secured a Perfect **10/10 GPA** in *3 out of 6 semesters*. Only student in the batch (1 out of 950) to have a 10.0 GPA in both the Freshmen semesters
- Secured **3 AP grades** (Advanced Performer) for exceptional performances in Linear Algebra (2^{nd} among 917), Biology (3^{rd} in 445) and Environmental Sci.& Engg (1^{st} in 269 students)
- Awarded the esteemed **DAAD scholarship** by the *German Federal Ministry* of Education and Research for pursuing quality research in Germany *2019*

KEY ACADEMIC PROJECTS

Temporal Data Support for PostgreSQL *Prof. S. Sudarshan | Fall 2018*

- Extended the open-source **PostgreSQL codebase** to add a new *valid-time* attribute, which allows a user to specify the temporal validity of a record in a relation
- Designed syntax for declaring **temporal relations**, which are relations having a valid time attribute
- Supported *natural and theta joins* among relations, irrespective of their type (temporal/non-temporal)

Language Processor for a subset of C *Prof. Uday Khedkar | Fall 2018*

- Designed a **compiler and interpreter** from scratch for processing a C style language
- Built support for *multiple variable scopes* and datatypes, along with control-flow, conditional and arithmetic statements
- The language also supports **recursion** and user-defined functions with multiple return-types

FPGA based Railway Signalling Controller *Prof. S. Chakraborty | Spring 2018*

- Automated a real-life Railway network using VHDL based FPGA boards as Signal Controllers
- Each controller supervised an 8-way junction by receiving live-data from adjacent controllers (UART connection) & central-server (encrypted USB-connection using FPGALink library)

GO Playing Bot *Prof. Amitabha Sanyal | Spring 2018*

- Used Monte Carlo Tree Search to create an automated bot for playing the board-game GO
- Designed a DFS-based graph algorithm for territory counting & used UCT in MCTS move selection.
- The bot created was able to make simple captures and perform counter-moves

Other Academic Projects

- *Natural Language Processing*: QnA website using Bayesian Taggers for tagging/grouping questions
- *Simulating Bokeh Effect in Videos*: Grab-Cut for getting foreground, emulating Lens Blur for Bokeh
- *Intel SGX Programming*: Coded Accountable Decryption, Merkel-Trees for decryption-requests log
- *Diagonal Parity*: Designed algorithm for 2-bit error correction using parity along 3 directions

ENTREPRENEURSHIP PROJECT

Kwikpic.in [`http://kwikpic.in/`]

- Employed a PCA and EBGM based facial recognition software to create a web-app for instant and secure procurement of event photos of a user
- Developed a proof of concept and negotiated with wedding and corporate event planners
- Optimized the algorithm to handle various lighting conditions, face accessories and expressions.
- Achieved recognition accuracy of $>90\%$ in indoor events & $>85\%$ in night events when field-tested

POSITIONS OF RESPONSIBILITY

Institute Web Nominee *Undergraduate Academic Council | 2018-19*

- Search Optimized the UG-academics website and improved visibility on the Google Search Engine
- Handled the Project Allocation Portal - used by 100+ professors with 3000+ applications
- Managed the TA selection portal (has 1500+ applicants, 20+ professors and all Freshmen courses)
- Created a Homepage-Generator for IITB (now no web-dev knowledge required to build homepages)
- Supervised crucial websites pertaining to Tutorials, Course Reviews, UG-Projects & Summer School

Web and Computer Secretary *Hostel 7 | 2017-18*

- Received the **Hostel Organizational Color Award** for exceptional work as Hostel 7 Web Secretary
- Designed an automated Parcel Notification System to inform the student on arrival of a package
- Created a Mess Rebate portal using PHP-Mailer to automate Mess-refunds for students on leave
- Automated Guest Room allotments, Library operations, Mess Menu updates & reinstated CCTVs

KEY TECHNICAL SKILLS & COURSEWORK

Software & Programming Skills: C++, Java, Python (incl. OpenCV, PyTorch, TensorFlow), Advanced Web Development, Prolog, Clingo, Scheme, VHDL, Matlab, Android Studio, QGIS, SolidWorks, LaTeX
Relevant Courses: Probability Theory, Statistical Inference, Derivative Pricing, Artificial Intelligence and Machine Learning, Digital Image Processing, Understanding Design (UI-UX), Remote Sensing

EXTRA-CURRICULAR ACTIVITIES

Sports : *Cricket:* 3rd Place in District Level Tournaments, 2 Man-of-the-Match Awards
Rifle Shooting: 1st Place in NCC Camp (.22 Calibre Rifle), Perfect Score in all rounds
Swimming: 1st position in the Summer of Sports Swimming Camp, at IIT-B

Community Service : Participated in the *Good Samaritan Mission, Vijay Ashram*, having 1800+ destitutes
Organized cloth (100+ kg) & blood-donation (60+ litres) camps in National Cadet Corps
Created a universal band to help patients easily track their medicine doses

Institute Bodies : *Entrepreneurship Cell*: Organized job fair for 1k+ students & 30+ companies at E-Summit
Innovation Cell (UMIC): Worked on the Line-Following bots and QuadCopter
IITB Racing: Worked on battery cooling & aerodynamics of the car to optimize downforce
Institute Summer Project(ITSP): Made a working **remote controlled beyblade** prototype

Awards: 3rd place in the Master Laureate Award - given for best overall record in High School
2nd place in Group Dance, Freshizza IIT Bombay